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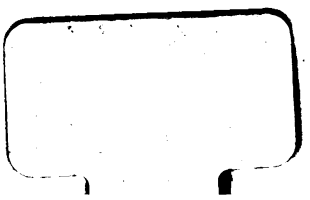

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THE

TRANSACTIONS

OF THE

LEEDS

Geological Association.

PART IX.

1893-94.

EDITED BY

W. LOWER CARTER, M.A., F.G.S.,

President.

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REPORT OF THE COUNCIL.

21st JUNE, 1894.

YOUR Council have pleasure in reporting a very fairly successful year, marked by an increased membership and a satisfactory measure of general vitality, indicated by a number of interesting excursions, and a good programme for the winter session.

The number of Honorary Members is 10; the number of Ordinary Members is 110; but an important departure from previous lines has been made in the admission of Associates and Student Associates. Seven Associates have been registered, and eleven Student Associates; and your Council hope for further extension in this direction.

Nine Evening Meetings have been held, and on the whole have been well attended. The papers and lectures have been of much interest, and the Association is indebted to several members for valuable contributions and assistance kindly rendered under pressure of many public and private engagements. The following lectures and papers have been given:—

1893.

Oct. 19. "A Petrological Description of Igneous Rocks," by Rev. W. Lower Carter, M.A., F.G.S.

"The Phenomena of Polarized Light," with Leech's patent polariscope lantern, by Mr. T. E. Hoyle.

Nov. 16. "A Peep into Nature's Sculpture Gallery," by Rev. W. Lower Carter, M.A., F.G.S.

Dec. 14. Holiday Notes. "The Mourne Mountains," by Mr. J. E. Bedford, F.G.S. "Cornish Geological Notes," by Rev. W. Lower Carter, M.A., F.G.S.

1894.

Jan. 18. "The Silurian System of Southern Scotland," by Mr. D. Forsyth, M.A., D.Sc.

Feb. 15. "The Rio Tinto Copper Mines," by Mr. R. H. Wood, M.I.Mech.E.

Mar. 15. "Mountains, Valleys, Lakes, and Fjords," by Mr. Theo. T. Groom, F.G.S.

Apl. 19. "Ancient and Modern Glaciers of North America," by Mr. Percy F. Kendall, F.G.S.

1894.

May 24. "Leeds Geologists in Norway," by Mr. D. Forsyth, D.Sc., M.A., and Mr. S. W. Cuttriss.

June 21. "Permanence of Continents and Oceanic Basins," by Mr. James H. Howarth, F.G.S.

Very considerable interest has been added to the evening meetings this year by devoting half-an-hour at the commencement to the exhibition of rocks, fossils, lantern slides, &c. The following is a list of the exhibits :—

Lantern Slides—Ceylon. The President, Mr. John Ingleby.
Do. English and Scottish Coast Scenery. Mr. Godfrey Bingley.
Canadian Plumbago and other Minerals. Mr. J. E. Bedford, F.G.S.
Silurian Fossils. Mr. D. Forsyth, D.Sc., M.A.
Fossils to show structure and mode of formation. Rev. W. Lower Carter, M.A., F.G.S.
Minerals and Fossils from Rio Tinto Copper Mines. Mr. R. H. Wood, M.I.Mech.E.
Cornish Pliocene Fossils. Mr. P. F. Kendall, F.G.S.
Carboniferous Limestone Fossils. Mr. J. H. Howarth, F.G.S.
Agates, Chalcedonies, Crystals, and Fossils in Flint. Mr. C. D. Hardcastle.

Including the Excursions of the Yorkshire Naturalists' Union, which the Association joined, twelve excursions have been held, viz. :

Ripon. Leader, Mr. P. F. Kendall, F.G.S.
Askern. (Y.N.U.)
Marsh Lane Cutting. Leader, Mr. B. Holgate, F.G.S.
Kirkby Moorside. (Y.N.U.) Leader, Rev. W. Lower Carter, M.A., F.G.S.
Eastby Moor. Leader, Mr. R. H. Tiddeman, M.A., F.G.S.
Gisburn and Sawley Abbey. (Y.N.U.) Leader, Mr. R. H. Tiddeman, M.A., F.G.S.
Wetherby. Leader, Mr. J. E. Bedford, F.G.S.
Rombald's Moor. Leader, Mr. P. F. Kendall, F.G.S.
Leathley. Leader, Rev. H. Canham.
Pecklington. (Y.N.U.) Leader, Mr. J. W. Stather, F.G.S.
Marsh Lane Cutting. Leader, Mr. P. F. Kendall, F.G.S.
Sedbergh. (Y.N.U.) Leader, Mr. R. H. Tiddeman, M.A., F.G.S.

The Council regret to record the departure from Leeds of the Rev. W. Lower Carter, M.A., F.G.S., but rejoice that the distance is not so great as to deprive the Association of his valuable services.

Obituary.

The Association has lost during the year two old and valuable members who have occupied seats in the Council, Mr. T. H. Gray and Mr. Wm. Cheetham, F.G.S. Their genial presence and counsel and ever ready services have been much missed; and also Mr. Jabez Hill, who for many years was a familiar and welcome figure at the meetings and excursions.

The loss sustained by Yorkshire geologists in the death of Mr. James William Davis, F.S.A., F.G.S., who was an Honorary Member of this Association, has been keenly felt; and your Council felt that the members would be glad to have Mr. Davis's portrait in Part VIII of the Transactions, in memory of a distinguished Yorkshireman, a good geologist, and a kind and genial fellow-member.

Through the efforts of your Council alterations have been made in the room, which they trust have added to the comfort and convenience of the members.

The Council have to gratefully acknowledge the following books received for the Library :—

Journal of Manchester Geographical Society, Vol. VIII., Nos. 4, 5, 6; Vol. IX., 1 to 6.
Annuaire Géologique Universel, Vol. XI., Part 1.
Report of Hull Geological Society, 1892.
Transactions of Manchester Geological Society, Vol. XXII, Parts 3, 4, 5, 9, 10, 11.
Proceedings of Geologists' Association, Vol. XIII., Parts 1-5.
Journal of Liverpool Geological Association, Vol. XII.
United States Geological Survey. Eleventh Annual Report, 1889-90, 2 Vols.
Transactions of Geological Society of Edinburgh, Vol. VI., Part 5, 1893.

PAPERS

READ BEFORE THE

Leeds Geological Association,

SESSION 1893-94.

OPENING MEETING OF SESSION.

OCTOBER 19TH, 1893.

The opening meeting of the new session was held in the Lecture Room at the Mechanics' Institution. Coffee was provided at seven o'clock, and a social half-hour was spent by the members prior to the work of the evening. At 7.30 the President (Mr. John Ingleby) took the chair, and in a short introductory address reviewed the work of the summer months and the prospects for the forthcoming winter. He congratulated the Association on the admirable changes which had been made in the Lecture Room. By the removal of the fixed lecture counter and gallery, the room had been rendered just what they required. Efforts had been made to extend the educational usefulness of the Association, and at the annual meeting it was resolved to enlarge the constitution of the society by the admission of science students as Associates at a reduced fee. In order to further the interests of these students it had been arranged to have a special exhibition and description of specimens during the half-hour before each lecture of the Session. A feeling reference was made to the serious loss sustained by the Association in the death of Mr. William Cheetham, F.G.S., one of its most active members, an ex-president, and for many years a member of its Council. The President then called upon Mr. T. E. Hoyle, of Blackley, to give his lecture demonstration with Mr. Leech's Patent Lantern Microscope and Polariscope.

Mr. Hoyle dealt with the complicated phenomena of polarised light in a very lucid manner. By diagrams he explained the method of obtaining a plane-polarised ray by double refraction through a rhomb of Iceland spar (polariser), and showed how by the introduction of a second rhomb (analyser) the ray was transmitted when the rhombs (Nicols prisms) were placed one in front of the other with the short diagonals of the rhombohedrons parallel. But when the analyser was turned through a right angle—i.e., when the Nicols prisms were crossed, the light was totally extinguished. By introducing a selenite film between the

crossed prisms, brilliant coloured light was obtained, selenite being a doubly refracting crystal. As the selenite was revolved, two positions were found in which the light was extinguished, these being the positions in which the two beams produced by the double refraction of the selenite were vibrating in the planes of polarisation of the polariser and analyser respectively. In intermediate positions two complementary colours of the spectrum were produced, the exact colours depending on the thickness of the film. By the use of a reflecting-glass analyser, Mr. Hoyle was able to throw both the ordinary and the extraordinary beams produced by the selenite on two screens placed at right angles to each other, the two complementary colours being thus seen at the same moment. Similar effects are produced by a thin plate of mica, and Mr. Hoyle had a number of beautiful geometrical figures made of mica films of various thicknesses which exhibited brilliant-coloured patterns on the screen. Two slides formed of a series of films regularly increasing in thickness, and movable one over another, showed the changes of tint due to alterations of thickness with picturesque effectiveness. The lecturer next proceeded with a brilliant series of illustrations of the interference figures produced when a convergent beam of polarised light is passed through sections of uniaxal and biaxal crystals. When a plate of annealed glass or a slice from a cubic crystal is placed in the line of such a convergent beam the light is unaltered, and if the Nicols be crossed no light passes. But if a crystal of a doubly-refracting substance be introduced between the polariser and the analyser, the polarised beam is broken up, and the convergency of the rays causes them to interfere with one another. In the case of uniaxal crystals, which include those of the tetragonal and hexagonal system, there is one direction, or optic axis, along which no double refraction occurs. When our crystal plate is uniaxal and cut perpendicular to the optic axis, the light passing along the axis of the convergent beam is cut off by the crossed Nicols. The same occurs along two directions at right angles, passing through this centre line, these directions coinciding with the planes of polarisation in polariser and analyser respectively. Thus a black cross is formed, and, in the quadrants between the arms of the cross, concentric rainbow-coloured rings are produced by the interference of the rays vibrating in planes other than those of polariser and analyser. When the Nicols are set parallel the complementary effect is produced, a white cross intersecting a series of circular rings, whose colours are complementary to those of the former series of rings. In biaxal crystals (rhombic, monoclinic, and triclinic systems) there are two directions along which there is no double refraction. When the convergent beam was passed through a thin slice of one of these crystals cut per-

pendicular to the line bisecting the angle between the optic axis, two eyes were formed united by a black band under crossed Nicols, the cross being completed by a transverse band bisecting at right angles the line joining the eyes. The interference rings, instead of being circular, in this case formed the figure of eight about the two eyes. When the crystal section was turned so that the line joining the axes was inclined 45 deg. to the plane of polarisation, there was a belt of brilliant colours between the eyes, and a dark hyperbola-shaped brush running transversely through each eye. Complementary colours were obtained with parallel Nicols. Mr. Hoyle also showed the curious interference figures produced by glass rapidly cooled, and also by a plate of glass subjected to pressure during the time that the image was on the screen. The phenomena of circular polarisation in crystals were also exhibited and explained, and the lecturer concluded by displaying the beautiful Airy's spirals formed by the superposition of a right-handed upon a left-handed quartz crystal section.

As a sequel to this splendid exhibition of polariscopic effects, a series of mineral and rock sections were exhibited on the screen by Mr. Leech's apparatus, and described by Mr. W. L. Carter, M.A., F.G.S. Petrology, the lecturer said, is the department of geological science that has for its object of study the characters and relations of rocks. Rocks are made up of various mineral substances aggregated together in different ways. Each mineral has a definite chemical composition, and crystallises in distinctive crystal forms. Minerals also have definite physical properties by which they are distinguished one from another, such as hardness, cleavage, colour, and streak. But the optical qualities of minerals were those with which they were chiefly concerned that evening. As Mr. Hoyle had demonstrated, minerals had the power of modifying the light that was passed through them, the modifications being evidenced when the light was polarised. Rocks also differed as to their mode of formation, the same minerals being fused together to form a granite, or merely mechanically mixed and cemented as in a sandstone. Some rocks were formed under great pressure deep in the earth, whilst others were poured out at the surface as lava. A brief examination of a number of rock sections was then made, the Acid group, largely composed of quartz, being first examined. Sections of granite and its chief constituents—quartz, felspar, and mica—were shown, and then the Syenite series, in which more basic minerals, such as hornblende, are found replacing quartz. The beautiful lattice-work growth-structure of Orthoclase felspar was well shown, and also the repeatedly twinned crystals of Plagioclase, and the glassy and liquid inclusions of quartz. The beautiful crystalline structures of chalcedony, jasper, and agate came out well on the screen, and

instances of spherulitic and perlitic structure were exhibited. Some specimens of the Basic series of rocks followed, including Dolerite, Basalt (from the Giant's Causeway), and Picrite (from Incholm). The series concluded with a section of contorted mica schist from Holyhead, and slides showing fine Zeolitic crystals, Silicified bone, Moss agate, and Luxullianite, a remarkable Cornish rock, full of beautiful radiating tourmaline needles.

The evening concluded with a short exhibition of new lantern slides by the President (Ceylon) and Mr. Godfrey Bingley, (Yorks.) A hearty vote of thanks was passed to Mr. Hoyle for his brilliant demonstration.

Mr. Joseph Lang, was elected a Member of the Association.

Miss Emma Church, Miss Martha B. Wadsworth, and Mr. H. A. Walker, were elected Associates.

Messrs. Walter Barrett, Charles V. Hartley, Douglas S. Loftus, Fred H. Haigh, Duncan Bennett, William Harrison, Thomas Wright, J. Forsyth, F. Wade, and R. Lyon, were elected Student Associates.

NOVEMBER 16TH, 1893.

Mr. JOHN INGLEBY, President, in the Chair.

A collection of fossils, to show structure and mode of occurrence in the geological strata, was exhibited and described by Mr. W. L. Carter, M.A., F.G.S.

The Hon. Secretary (Mr. W. L. Carter) read a letter from Mr. Robert T. Litton, Hon. Secretary of the Geological Society of Australasia, desiring to become a Corresponding Member of the Association, and nominating the following gentlemen for membership:—Messrs. R. T. Litton, A. Kelly, F.G.S.A., A. Clarence-Johnston, M.E., F. H. McKnight, F.G.S., E. Cox, M.E., and J. B. Dean, F.R.H.S., of Melbourne; Mr. E. Payne, M.I.M.E., of Ballarat; and Mr. E. J. Alexander, J.P., of Creswick, Victoria. These gentlemen were unanimously elected Corresponding Members of the Association.

The President announced that a lecture was to have been given by Mr. William Horne, F.G.S., of Leyburn, on "The Early Races in Yorkshire," but at the last moment a communication had been received saying that he was suffering from a severe cold, and much regretted his inability to be present. His place was taken at very short notice by the Hon. Secretary, who delivered a popular lecture on Denudation.

"A PEEP INTO NATURE'S SCULPTURE GALLERY,"

By Mr. W. LOWER CARTER, M.A., F.G.S.

This world is a world of wonders. If we look above to the

starry universe, we may be impressed with the insignificance of the globe we inhabit; but if we observe attentively the changes which the surface of the earth has undergone, and still is undergoing, we cannot but wonder at the stupendous work that is going on in the world around us. The work of Nature in shaping hills and carving valleys, in forming plains and cliffs, spires and gorges, is the subject matter of this lecture; but as we look into Nature's studio we shall not only be able to admire her finished work, but to take many glances behind the scenes, watching the invisible sculptress at work, and examining the tools by which she accomplishes her ends. We are astonished at colossal pyramids and magnificent cathedrals, the proud work of generations that have passed away; but Nature has far outdone these. Beside her giant works their mass assumes but a pigmy form. Age after age Nature has piled up great courses of masonry, and in some cases pressed them together, and bent them into mighty mountain masses. Then, during long ages of patient work, she has carved them into vast pyramids thousands of feet in height. Further investigation teaches us how great are the changes that have thus been effected. Mountains must once have reared their heads where now plains spread out their tablelike flatness. Elevated tablelands, which once stretched uninterruptedly for hundreds of miles, are now only represented in fragments by widely separated hills. The greatness of these changes was a considerable hindrance in days gone by to a clear and true interpretation of these phenomena. Men looked to revolution, instead of to evolution, for a solution of the mystery. They imagined fierce convulsions rending hills in twain. They supposed mountain masses to have been suddenly elevated from ocean depths by gigantic earth throes which sent mammoth waves careering over the land, carrying rocks away wholesale. So, looking for cataclysms unlike anything known to-day, they were tempted to despise the modest agents that have acted through ages past as quietly and effectively as they are doing to-day, producing the continual transformation scene that has been progressing ever since the land first reared its crest above the waters. The work of geological sculpture may be likened to figure carving in the case of mountain sculpture, but usually more closely resembles the carving of a memorial stone, in which the original flat slab is shaped into some ornamental form and grooved with a variety of patterns.

In studying Nature's handiwork our attention is first directed to the striking features of a country, its outline, its mountain masses, its wide-stretching plains. The present outline of Britain, for instance, is the result of long ages of change; elevation and depression, denudation and deposition succeeding one another; the land sometimes gaining on the sea, the sea in its turn

vanquishing the land. The dominating features of a country's surface contour are determined largely by the age and hardness of the rock. As a rule, the older the rock and the more compact and resistant has it become. Thus we find the older geological strata forming the great mountain masses of our islands, while as we pass eastwards we cross a series of hill ranges and plains produced by the alteration of secondary limestones and clays, whilst the newest and least consolidated strata are found in the flat lands of the east coast. These greater divisions of land sculpture are broken up by a variety of detail, deeply grooved notches and smoothly rounded slopes, elaborately fretted pinnacles and steplike escarpments, graceful arches and subterranean caverns—showing not only the vastness, but also the extremely varied character of Nature's handiwork. This sculpture is effected by the action of certain cutting agents, which Nature uses as her tools.

Marine Denudation.

I. The Sea—Nature's planing machine.—The action of the sea is threefold.—(*a*) Chemical, producing decay of the rocks. (*b*) Mechanical, bombarding the cliffs by the tremendous battery of the breakers, which catch up the shingle and hurl it with tremendous force against the shore, the cliff itself providing the missiles by which it is being slowly battered to pieces. (*c*) Hydraulic, by forcing the water into fissures. The power of the breakers in a storm is tremendous. As they dash into a cleft the water drives forward the air with great force, and produces a considerable pressure in the interior of the cliff. The water itself filling the many crevices exerts a powerful hydraulic force that aids mightily in forcing the rocks asunder along planes of division. This denuding influence of the sea is only exerted within a comparatively narrow range; that is, between high and low water, and a short distance on either side of these water marks. Thus the sea can only eat its way into the land horizontally, and the result of its work is a plane covered by comparatively shallow water, which when elevated would form a tableland.

That the sea has been working in the same manner over and over again during geological time, when the land was at a lower level, we have ample evidence. Many observers have been struck with the similarity in the height of the hills in certain areas, independently of the rocks of which they are composed. Professor Ramsay was the first to attribute this equality to the action of the sea, and to give it the name of a plane of marine denudation. The remnants of such a plane we have in North-West Yorkshire, the present hills of that region, Ingleborough, Penyghent, etc., being isolated patches of what once was a table-land planed down by the sea.

The result of coast denudation on a series of beds of homogeneous character would be the production of a straight line of cliffs, but the actual outline is much affected by the varying hardness of the beds, and the direction of the prevailing wind. The harder rocks stand out in headlands, while the softer beds are washed away to form deep bays. It is estimated that the average rate of coast erosion is ten feet in a century, and at that rate it would take 50,000 years to cut a slice one mile in width from our island coast.

Taking the Yorkshire Coast as an example, the Chalk of Flamborough Head stands out boldly, but the soft clay and sandy beds of Holderness suffer considerably by the action of the waves. It is estimated that the cliffs between Bridlington and Spurn Point recede seven feet annually; that is a loss of thirty acres of Yorkshire land each year. The sites of many ancient towns and villages are now sandbanks. Passing southwards to Norfolk we find the German Ocean covers the site of Old Cromer and other once flourishing towns, and the cliff is now being wasted at the rate of fourteen feet per annum. Perhaps many an inhabitant of East Anglia to-day sighs forth as his own the pathetic lament of Crabbe:

> "Ah! hapless they who still remain;
> Who still remain to hear the ocean roar,
> Whose greeny waves devour the lessening shore,
> Till some fierce tide with more imperious sway,
> Sweeps the low hut and all it holds away."

The same work is going on all round our coast, its rapidity depending on the nature of the rocks forming the shore-line.

Sub-aerial Denudation.

As we look around we find that as the sea cuts sideways, other agents are cutting the land downwards, carving into the level surfaces left by marine denudation. These agents, though apparently too insignificant for such mighty tasks as the production of our hills and valleys, are yet found, by the aid of Old Father Time, to be capable of achieving the mightiest pieces of earth-sculpture.

(II). River Action.—Running water acts on the rocks over which it passes by a two-fold denuding power. (*a*) Chemical. Water dissolves portions of all the rocks, and rapidly disintegrates some of them. This action is vigorously aided by the carbonic acid which the water holds in solution. For instance, it is estimated that the Thames carries to the sea one ton of salts in solution every minute. (*b*) Mechanical. This is accomplished by the sand and gravel which the river carries along, and by means of which it wears away its bed. Streams act thus in three ways. (*a*) Cutting down, as a rasp or file. By this means the

river works its way through rocks, taking advantage of joints or other planes of weakness, forming gorges when the beds are hard, and smoother slopes when softer strata are traversed. The channel is continually deepened so long as there is sufficient fall for the water. (*b*) Cutting back, as a saw. This work is done by the waterfall which usually occurs where a hard bed crops out in the course of a stream. The wash of the water wears away the softer underlying beds, and the capping rock breaks off along joint planes from time to time. Thus a gorge, or defile, is gradually produced. (*c*) Cutting sideways, as a shovel. When a river emerges from the hilly districts of its birth it loses its vigorous rush, and begins to flow with slow and steady sweep towards the sea. It can now no longer deepen its bed to any great extent, but the motion of the stream causes it to flow in wide loops, the velocity being greatest at the outside of each bend, whereas on the inner and more sluggish side material is dropped down. Thus a river traversing a plain continually shifts its position, working sideways into the beds through which it flows.

Rain and Temperature.

(III.) Natures Picks.—These are agents for loosening the ground and preparing it for the effective action of river and sea. (*a*) Rain acts chemically on many rocks by the carbonic acid it holds in solution, and this action is especially powerful on limestone beds. Rain also acts mechanically, washing the soil from higher to lower levels, and continually exposes fresh surfaces of rock for the action of denuding agencies. (*b*) Changes of temperature are very effective in rock disintegration, especially in exposed situations and on mountain summits. The rocks are expanded by the heat of the day, but they contract rapidly at night-time. In this way cracks are opened, joints widened, and pieces fly off. (*c*) Frost is a very effective agent at high altitudes, and against the slopes of every mountain lie great banks of rocky fragments, which are called screes. In the autumn and winter the pores of the rock become saturated with water, and the cracks are filled with damp snow or soil. The water alternately melts and freezes, and by its expansion pieces and blocks are wedged off, which fall down in abundance each spring. Frost also exercises a considerable influence in the disintegration of damp soil. The particles are pushed asunder by the freezing water, and when the thaw comes there is no coherence in the soil, and it is easily washed to lower levels.

(IV.) Nature's Grooving and Polishing Machine—the Glacier. Snow accumulates in large quantities at altitudes above the snow-line, and, compressed into ice, creeps down the valleys that radiate

from the snow-field, grooving the rocky surfaces over which it passes, and scratching them by means of sharp stones frozen into its under surface.

By these various tools Nature carries on her increasing work of rock-sculpture. The present shape of the coast-line and the outlines of the land masses are due to the activity of these agents through tens of thousands of years of unceasing work. Their tendency is ever to reduce the surface of the land to a dead-level—the sea by working sideways, and the rivers and atmospheric agents by working it in various ways downwards. The harder and more compact rocks resist this wear and tear, standing out into the sea as promontories, and up into the air as hill ranges. Illustrations of Nature's handiwork lie open to the observant eye on every hand. An old pit mound, that has been exposed to the action of the weather for years, will give a very good idea of the way in which a table-land becomes separated into distinct hills and the valley system of a country is developed. The smallest brooklet can teach us facts which are as true for it as for the Mississippi or the Congo. The power of rain and frost as disintegrators are apparent in a railway cutting or on a road-side bank, and even the ground under our feet in early spring speaks eloquently of the same strange activity. Nature's sculpture gallery lies open on every hand inviting us to its investigation, and promising rich rewards of healthful recreation and mental stimulus.

The lecture was illustrated by 100 beautiful photographs, kindly lent by Mr. Godfrey Bingley, and a vote of thanks was passed to the lecturer at its close.

DECEMBER 21st, 1893.

Mr. John Ingleby, President, in the Chair.

HOLIDAY NOTES.

"THE MOURNE MOUNTAINS,"

BY Mr. J. E. BEDFORD, F.G.S.

The portion of Ireland referred to in this paper is easily accessible from Leeds, but still comparatively unknown to English tourists. It is so near to our shores that its fine group of mountain peaks can be seen on clear days from the Isle of Man, or even from Wales, and yet few people know anything about it from personal observation. Lovers of bold mountain scenery can be confidently recommended to the county of Down; there they will find scenery of a very varied

character—sixteen or eighteen mountain peaks, bounded by the Irish Sea on the east, Carlingford Lough on the south-west, and the plains of Armagh to the west. To the artist there is endless material for study. Many of the hills are green to the summit, others are clothed with purple heather, a perfect blaze of colour. Forests of firwood cover the flanks of the hills and fill the valleys, in some cases reaching down to the sea itself at high-water level. The beautiful little town of Rostrevor is so completely hidden in trees that only the spires of two churches show its whereabouts. The Mourne Mountains rise precipitously from the sea at this point, the first hill being 960ft., whilst immediately behind it is Slieve Ban, 1,595ft. Across the bay, at a distance of three miles, we see the long range of the Carlingford Hills attaining 1,935ft. To the geologist the Mourne district is of very great interest. Professor Hull, director of the Geological Survey of Ireland, who has given special attention to this interesting group of hills, writes as follows in his "Physical Geology and Geography of Ireland": "The Lower Silurian rocks in their normal condition consist in the lower part of dark schists with graptolites, cleaved and interstratified with lenticular bands of grit, the whole representing the Llandeilo beds of North Wales; and in the upper of grey and greenish slates, grit, and fine conglomerates, in some places calcareous and fossiliferous, and in a few localities containing beds of limestone. These are the oldest fossiliferous limestones in Ireland, and may be considered as the representatives of the celebrated Bala limestones of North Wales." "In the districts north of Dundalk Bay and flanking the shores of Carlingford Lough these strata have been penetrated by granite and plutonic rocks forming the Mourne and Carlingford mountains, while along a line of country extending from Slieve Gullion to Slieve Croob they have been converted into granite by a process of intense metamorphism." "The Mourne and Carlingford mountains may undoubtedly be considered as the roots of volcanic mountains, the trunks and branches of which have been removed by denuding agents; just as if a mountain like Etna were cut down into a group of hills rising 2,000 or 3,000 feet above the level of the Mediterranean. The intrusive character of the rocks, the association of felspathic and pyroxenic varieties, as in the case of the more recent volcanic mountains, the innumerable dikes of trap which radiate from, or traverse, the whole district, all point to this region as having been the seat of great volcanic activity. Nor ought we to omit reference to the remarkable mass of agglomerate made up (as on the southern flanks of Slieve Gullion) of bombs of granite which have been torn up from the granitic bases of the hill below, and blown through the throat of an old crater, as conclusive evidence that these rocks in some

places were erupted at the surface of the land of the period." At Carlingford intrusions of basalt are to be seen traversing the Carboniferous Limestone, and on Slieve Foy the limestone is converted into crystalline marble at its contact with the hypersthene dolerite. "The mountains of Mourne are composed of a peculiar granite—it consists of orthoclase, albite, quartz, and mica, and it is full of cavities, which often contain beautifully formed crystals of smoke-quartz, orthoclase, topaz, and most rarely of emerald. It is of intrusive origin, sending dykes and veins into the Lower Silurian rocks with which it comes in contact, and is itself traversed by dykes of basalt, felstone, mica-trap, and porphyry. There are other dykes, however, of similar rocks, which are older than the granite." "The Mourne Mountains consist generally of a series of conical or dome-shaped elevations, of which Slieve Donard, itself forming the culminating summit, is a fine example, rising from the margin of the sea to 2,796 feet. This is generally the form assumed by granite in mountainous districts; still, serried ridges and peaks are not absent from this range, examples of which we find in Slieve Bingian (2,449ft.) and Slieve Barnargh (2,394ft.)." Professor Hull considers that these mountains were erupted during the Permian period. The intrusive dyke in the Rostrevor quarry is largely worked for paving sets, and for this purpose it is said to be superior to the Aberdeen or Mount Sorrel granites, because it does not become polished and slippery with heavy traffic. There is, lying on the mountain behind Rostrevor, at an elevation of 957ft. above sea level, a boulder of grey granite, 1½ft. long and 9ft. high, estimated to weigh about 30 tons. The granite is similar to that about Newry, away to the north-west. Also on the road to Newcastle, near Annalong, there is a boulder of large size and much rounded. It is about 15ft. in height and 20ft. long. The summits of many of the mountains are very rugged, offering good examples of denudation. Carlingford Lough is an example of a fiord on a small scale, being 16 fathoms deep at the centre, but only 4 fathoms at the entrance from the sea. It is a rock basin, and the direction of the ice-flow nearly coincides with the direction of the valley at Newry and the fiord. Boulders of granite are strewn about in all directions; miles and miles of walls are constructed of them, obtained from the cultivated land. There are thousands to be seen from any point along the coast road skirting the mountains to Newcastle from Rostrevor. They are found to an elevation of 1,200 feet above sea level on the ridge above Follymore Park; and glacial wearing of rock is to be seen to a height of 1,500 feet. In conclusion, the lecturer alluded to some delightful days spent in walking, driving, sketching, and picnicing among lonely mountains and the beds of rocky streams comparatively dry with the drought of summer, a

beautiful lake basin embosomed in hills, a silver strand of the purest white, plateaux of decomposing granite crunching under the tread, and at night a glorious drive by Kilmorey Park, with its mountain of the purplest heather, the full moon rising and glistening on the waters of the Lough, and through the wood by night, a darkness to be felt, after leaving the moonlight, and home to a well-earned rest.

Note by Mr. J. E. Bedford, F.G.S., 6th Jan., 1894.

I have a letter from Professor Hull saying that he had seen my paper on the Mourne Mountains in the *Yorkshire Post*, and adding "I need scarcely say how gratifying it is to me to see English geologists turning their attention to this remarkable group of mountains: so worthy of study both from their physical features and geological structure" etc. Also "that in the new edition of the 'Physical Geology of Ireland, 1891" I have modified my opinion regarding the geological age of the Mourne and Carlingford Granitic Rocks which may not improbably be coeval with the Granites of Arran and those of Mull. This is of course a matter of inference or conjecture, as direct evidence is unfortunately wanting."

"A WALKING TOUR IN CORNWALL,"

By Mr. W. LOWER CARTER, M.A., F.G.S.

A Midland express took the geological tourists as far as Cheltenham, where a brief halt was made in order to ascend Leckhampton Hill, with its quarries far-famed in geological lore. A bright evening afforded a grand view over the wide valley of the Severn, carved out of the New Red Sandstone, and backed in the far distance by the bold outline of the Malvern Hills, oldest of English relics of creation. On through Bristol, with a glimpse of its far-famed gorge, with the limestone beds on either side bent into curious folds by primæval earth movements, and then swiftly across the Somerset and East Devon plain to Exeter, where a halt was made to view its quaint, busy streets, the curious little black Guildhall, teeming with historical reminiscences, and the grand old cathedral. Then to quiet Dawlish, a haven of rest for the night, clean, pretty, and neatly built on each side of the clear, running stream, fringed with grassy lawns. The railway between the mouth of the Exe and Teignmouth runs along the base of the cliffs, which are composed of masses of New Red conglomerate and sandstone of the deepest hematite-red. These cliffs are easily denuded by the sea, every turn evidencing the rapid progress of marine denudation, outstanding blocks or spires showing the previous limit of the cliff-line. Torquay, most picturesque of

watering-places, merited a longer stay than we could devote to it, with its winding, beautifully wooded roads and continually changing peeps of the blue sea. Go which way you will, the road always seems to arrive at some delightful bay or cove. A walk to Babbicombe enabled us to admire the picturesque boldness of the Middle Devonian limestone cliffs at Anstis Cove, and a stroll over the breezy golf-links was very enjoyable. The sea wall of great limestone blocks, passed on our return, was a veritable geological museum, being full of corals, but not available for our fidgety hammers. The geology of Western Devon and Cornwall has been described in a picturesque phrase as "Four or five islands of granite rising from a sea of clay slate." The most easterly of these granite masses is Dartmoor, which is skirted by the train for Plymouth, and the other masses lie in a line curving to the south-west, forming the axis of the Cornish peninsula. Dartmoor, the largest of these granite bosses, occupies an area of 225 square miles. Sixteen miles to the west is the Brown Willy mass, which covers 65 miles of surface. Five miles farther the St. Austell granite is reached (35 square miles), in the neighbourhood of which are found the blocks of Luxullianite, which are so noted. In another 15 miles we come to the round Penrhyn patch (55 square miles), and seven miles due west of the last-named is the Land's End boss (65 square miles), whilst away over the wave-covered lands of fabled Lyonesse is the sixth, the Scilly mass, broken up into a multitude of picturesque islets. The old-established theory of the origin of these granite bosses is that of "intrusion." The molten rock is supposed to have invaded the Devonian and Carboniferous strata, bending, absorbing, and altering. Support is given to this theory by the fact that the beds round these granite masses are deflected and their strike modified. The strata in immediate juxtaposition to the granite have suffered considerable alteration, and tongues of igneous material are protruded into the sedimentary beds. Mr. W. A. E. Ussher, however, who was on the Geological Survey of this district, argues powerfully that these disturbances and alterations do not appear to be due to or connected with the upheaval of the granite, but are shown by evidence to arise from great earth movements, the action of which has been impeded by the solid granite masses, which maintained their original outlines, and thereby exercised considerable mechanical alterations in the strata forced powerfully against them. The metamorphism of the fringe of the granite and the adjoining beds would on this latter theory be explained by the great frictional heat developed at the edges of the obstructing rock masses, by great mechanical movements acting on materials unequally consolidated. There seems considerable evidence in favour of the deep-seated connection of these

granite masses one with another. Such a view as this seems very difficult to reconcile with the intrusive theory. If the granite had been intrusive into pre-existing sedimentary beds it would probably have taken the form of a laccolite, piercing the rocks in a wide neck in the lower parts of its course, and then spreading out mushroom-like when it was easier to lift the superincumbent beds than to fracture them. If these bosses are connected below the surface it points to their being part of pre-existing land, by the denudation of which the Devonian beds may have been formed, as they appear to have been derived from rocks of that nature. The consolidation of the granite in its present aspect is pre-carboniferous, but the rock in which this alteration has taken place probably dates back to Archæan times. Dikes of acid rock (elvans) pierce the Devonian strata and the granite also, and conform to the general strike lines which have been produced by the great east and west lines of shrinkage which contorted the Palæozoic strata of the West of England, probably in Permian times. Parallel to this granite ridge the railway runs to Penzance, giving a glimpse of the dreary china-clay workings of St. Austell, and of England's newest cathedral at Truro. One of the most picturesque features of Cornish coast scenery is Mount's Bay, with its craggy granite island, crowned by the picturesque towers of the old castle of St. Michael. The Archangel is said to have appeared there to some hermits in the year 490. In 1047 a Priory of Benedictines was established by Edward the Confessor, and since then the castle has seen many a "merry" time during the various civil wars of Old England. From Penzance a pleasant day's expedition was made to the Land's End, the ride being across the bleakest and barest of moorland, only beautified by the bright yellow gorse. Alighting at the little hamlet of Trereen, we walked to the Dinas, or castle, a peninsula of granite, on the summit of which stands the great Logan, or rocking-stone, which is said to weigh over 60 tons. A gay young lieutenant in the navy, for a bet, upset this huge mass on to the beach in 1824, but had to pay dearly for his joke. The upsetting was very easy, but when it came to putting "Humpty-Dumpty" up again, it was quite a different matter. However, it had to be done, and, by the help of tackle borrowed from the Admiralty, the Logan was restored to its perch, to the sore damage of the lieutenant's pocket. A walk across the whitest of quartz sand at Porth Curnow brought us to a bank of primroses, on which we reclined at lunch-time. Then onward our way lay by a cliff path round Land's End, in full view of romantic coves, with sides of jointed granite blocks, mimicking castle walls, giant's ladders, &c., and giving most instructive lessons on the work of denudation. A cautious look was taken into the deep chasm called "The Funnel,"

due to the falling in of the roof of a sea cave; and afterwards a rocky climb in the evening grey brought us to the extreme west of our island home. A trip to the Scilly Isles on a small steamer gave us a fine view of the granite cliffs—a wide berth being given to the dangerous Wolf's Rock, crowned by a fine lighthouse and said to be the only locality where phonolite is found in the British Islands. A quaint, quiet people are the Scillonians, inhabiting only four or five of the numerous granite rocks which compose this group. St. Mary's is the chief island, the pride of which is Hugh Town, with its star fort, dating from the days of Queen Elizabeth, and its modern harbour, centre of the spring flower trade, which is now the life of Scilly. A sail over to Tresco enabled us to see the famed tropical gardens belonging to the Lord Proprietor, with glimpses of ever-varying beauty as the island panorama moved past. Only a narrow strait separates Tresco from Sampson, with its twin hills, barrows, and deserted cottages, to every reader of Walter Besant haunted by the sweet presence of "Armorel." We next exchanged the granite cliffs of Scilly and Land's End for the remarkable serpentinous rocks and the wild beauty of the Lizard coast, hewn out into many a cave, and worn apart into pinnacles and rocky islets. Little time was left for the examination of this complicated mass of altered igneous rock, but specimens were obtained of the characteristic rich-red serpentine, with its varied and beautiful steatitic veining, and an outcrop of the tough grey schists was found near the lighthouse. The gabbro of St. Keverne, intrusive into the serpentine, furnished additional specimens for our bags, and then geology had to be put aside for a stiff walk across the moorlands, made gay with masses of golden-yellow gorse. Thence, by picturesque Helford and over the ferry, many a flowery lane and field-path was traversed to Falmouth, and then "Northward ho!" once more.

The evening was concluded with the exhibition of a splendid series of photographs by Mr. Godfrey Bingley, including some new Yorkshire views and numerous beautiful pictures of picturesque west-country villages. A number of fine coast views in Somerset, Devon, and Western Scotland gave interesting evidence of the ravages of the sea on our island coast.

At the commencement of the proceedings feeling reference was made by Mr. J. E. Bedford and Mr. Hardcastle to the loss sustained by the Association in the death of Mr. T. H. Gray, and a vote of sympathy and condolence with the members of his family was passed unanimously.

JANUARY 18TH, 1894.

"THE SILURIAN SYSTEM OF SOUTHERN SCOTLAND."

By Mr. DAVID FORSYTH, M.A., D.Sc.

GENERAL DESCRIPTION OF THE SILURIAN SYSTEM OF SOUTHERN SCOTLAND.

From the rocky cliffs of Portpatrick to the precipices of St. Abb's Head there stretches a broad band of high land. The northern boundary of this area consists of a sinuous line stretching from the mouth of the Girvan Water to the mouth of the Tyne in Haddingtonshire; and the southern boundary stretches from the mouth of the Nith in a line, even more broken, to the mouth of the Tweed. This area comprises a ridge of genuine mountain land, including such heights as Merrick, Cairnsmore, Black Larg, and others, near the head-waters of the Cree, Dee, and Ken; the Lead Hills, Lowther Hills, with such heights as Queensberry and Hartfell, near the upper waters of the Clyde, the Annan, and the Tweed; with the lower elevations of the Pentlands and Lammermoor Hills to the eastward. This mountain land has not the bold outlines, the rugged precipices, or the picturesque majesty of the Highlands of Scotland, where the massive Grampians heave summits a thousand feet higher into the air. Yet it is a land with not only characteristic features of its own, but an infinite charm which begets an absorbing love in the bosom of the lonely wayfarer who seeks its mountains or its dells for treasures of geological and botanical value, or its clear streams in pursuit of "the gentle craft." This is the land which had such an influence on Scott, and with which he is as much associated as Wordsworth is with the English Lake District.

I have wandered over most of it and everywhere I have found the same kindly welcome, the same healthful occupations, and the same, and yet not the same, geological problems. The fresh mountain air, the plain fare, the varying successes of "blank" and "lucky" investigation, and the variable weather, are the joys and sorrows of the mountaineer.

Here is Scott's picture of such a land:—

> "The rugged mountain's scanty cloak
> Was dwarfish shrubs of birch and oak,
> With shingles bare and cliffs between
> And patches bright of bracken green,
> And heather black, that waved so high
> It held the copse in rivalry.
> And oft both path and hill were torn
> Where wintry torrents down had borne
> And heaped upon the cumbered land
> Its wreck of gravel, rocks, and sand."

This is the land associated with much of the life of Burns, and many a pilgrim has sought Dumfries to muse over the ashes of one whose words are the flashes of a genius which idealised Scottish home-love, affection, and patriotism.

The valleys are, as a rule, formed at right angles to the main ridge or axis of elevation, and stretch N.W. or S.E. towards the sea. Towards the north-west runs the Doon, "the bonnie Doon" of song and story, "Ayr's winding stream," and the Clyde. Towards the south-east flow the Luce, the Cree, the Dee, the Nith, and the Esk. Running parallel to the main line of elevation flow the Girvan, the Stinchar, and the picturesque App, while crossing the ridge runs the Tweed. These valleys present every variation of river scenery; originating in lonely lochs or bleak hill-sides, their streams rush, forming ravines like Ness Glen through a succession of wooded straths like the Nith, or through fertile plains like the Girvan, or through miles of pasture land like the Tweed, or by a succession of falls as in the Clyde. All are beautiful in their own way, and all excite thoughts of power, of freedom, of onward movement.

The lakes are usually small, at least in comparison with the lakes of the Highland area, but yet beautiful in their own way. The bare Loch Doon with its glacial "scoop" has near it "the gem of the wilderness," Loch Trool, and lying on the mountain-side you can count a score of lochs within easy vision; while Loch Skene in its barren ruggedness, and suggestive glacial mounds, is a contrast to the lonely St. Mary's Loch.

The mountains are seldom rugged, but rise rather in gentle mounds or swells, and the lower hills towards the margin of the area display the same features. And to any of you travelling from Leeds to Glasgow I would recommend a look north-east towards the Lead Hills after passing Carron Bridge Station, for there at a glance you have all the features of the Southern Highlands.

I have endeavoured to analyse the nature of the liking which grows on one for these Southern Uplands till it becomes almost a passion. It is not beauty alone, it is not majesty or sublimity, for these qualities are seen only in small areas, or in detached parts. The feeling produced by the general effect of the uplands is that of open, unrestrained communion with nature:—the long stretching scene, with its distant horizon, the endless roll of mountain swells, the undertone of pensive sounds, for the "soughing" of the moorland wind, and the notes of the moorland birds are pensive, almost melancholy. The unfettered mind is open to every impulse of nature, from the tiny moorland flower, from the sheen of the lake, from the changes of sunshine and shade flecking the landscape with lights and darks in keeping with the moving clouds. All these combine to make a man love

the moors. But need I say in a gathering of Yorkshiremen what this upland feeling is. You have it. And your authors have it. It was it that moulded and environed your Brontes, and made them classic.

A.—The Relation of this Silurian System to other Formations in Southern Scotland.

Both sides of the Silurian area are flanked by Old Red Sandstone deposits. Towards the N.W. in S. Ayrshire, in the neighbourhood of Girvan, Barr, and Straiton, lies an extensive tract of Old Red Sandstone rocks that stretch to the Heads of Ayr, gently dipping seaward. While on the borders of Lanarkshire and Ayrshire, in the Muirkirk, Douglas, and Lesmahagow districts, is another area of the same formation dipping gently in the same direction to the N.W., towards the Carboniferous valley of Central Scotland. The same Old Red Sandstone formation is found coming close up to the Upper Silurians of the Pentlands, although an intervening fault hides much of their relations. On the south-east of the Silurian area is a smaller Old Red Sandstone area, filling the level ground round Berwick, and thence passing into Northumberland, and abutting against the Cheviot Hills, which may be said to be included in the area as the representative of the volcanic activity that marked the close of the Old Red Sandstone period, and the beginning of the Carboniferous.

B.—Relation to Carboniferous Strata.

In the Girvan district the coalfield lies faulted between two Silurian areas—the smaller to the N.W., including the famous Mulloch Threave and Craighead deposits, and the southern being part of the great Silurian uplands. In the Sanquhar coalfields the Carboniferous deposits are laid down upon the denuded edges of the Silurian strata, and this fact leads Sir A. Geikie to think that the Carboniferous rocks extended over a much larger portion of the Silurian area.

Towards the N.E. the Lothian coalfield is faulted against the Silurian rocks of the Pentlands, by the same series of faults that has disturbed the relation of the Old Red Sandstone to the Silurian.

Towards the south-east from near the entrance of Kirkcudbright Bay, a series of Carboniferous rocks lie fringing the shore, and it is a wondrous experience at Balmae Head to walk in 100 yards from Silurian Graptolites to the shells and ferns of the Carboniferous formation. And the same formation extends inland from the Solway, by the valley of the Esk, to the foot of the Cheviots. While on the west side of Loch Ryan are rocks that from their

fossils are distinctly Lower Carboniferous. These extend about five miles along the shore, close to the sea, and are only two or three hundred yards wide being covered by a band of Permian strata.

C.—Intrusive Rocks.

Three large areas of granitic outburst are worthy of note—one stretching from near Dumfries to Kirkcudbright, and including such heights as Criffel and Cairnsmore of Fleet; another stretching from the head of Wigtown Bay to the head of Loch Ken, and including in it Cairnsmore of Dee; and a third occupying the lofty ground along the mighty trench at the head of Loch Doon, with Merrick and other heights.

Eastwards from this last granitic area lies a smaller granitic boss, that of *Cairnsmore* of *Carsphairn*, and within the northern boundary of the Silurians is a smaller boss still, known as *Spango* Granite. This Spango granite has a considerable proportion of pink orthoclase in its structure; and its ice-borne boulders are therefore, easily recognised.

Most of these granitic bosses are volcanic outblows that have thrown out some of the superincumbent rocks, and have largely altered the others.

D.—Inliers of Newer Rocks.

Lying like basins enclosed in Silurian rocks are two series of Permian areas, in the valleys of the Nith and Annan. Around Dumfries and skirting the east side of the estuary of the Nith, lies the largest of the Permian areas of the valley. It consists of breccias and brick-red sandstones, and their small amount of inclination points to their deposit in a calm lake. From their evident connection with the Permians of Annan it is apparent that the Scottish strata are continuations of the Permians of Cumberland, and that an extensive lake of Permian deposits once stretched from the base of the Cumberland Hills to the Lowthers. In the Dumfries area the Permians lie unconformably on the upturned Silurian rocks.

Further north in the Nith valley there is an extensive area of Permian strata overlying Carboniferous Lower Limestones and Calciferous Sandstones, and in some districts overlapping them and lying unconformably on Silurian rocks.

In the valley of the Annan are two similar patches near Lochmaben and Corncocklemuir. It is noteworthy that these sandstones are interbedded with beds of porphyrite, evidently old lava flows; and also from the fact that in the same sandstones have been found footprints of a Labyrinthodont. (Some slabs with these markings are seen in the Edinburgh Museum of Science and Art, near the main entrance). It is in these basin

remains that one sees the foundation for the theory that the Silurian area was more largely covered with newer formations—Old Red Sandstone, Carboniferous, and Permian,—and that these overlying rocks have been removed by the excessive denudation to which the upland area of Southern Scotland has been subjected, the sheltered patches lying in the hollows alone remaining to testify of the more wide extent of deposit in former geological times.

Glacial and Post-Glacial Deposits.

The glaciation of this upland district is so marked, and its results so varied and important, that I must leave all reference to this interesting part of geological enquiry to some other time, when it can receive your undivided attention. Suffice it to say that this district exhibits all the phenomena of striæ, ice-carried boulders, perched blocks, boulder clay, kames, which delight the soul of the glacialist. And round its coasts in sheltered nooks at Girvan, Stranraer, &c., are post-glacial clays.

A.—The Girvan Area.

This district is one of the most interesting, and certainly the most fossiliferous, of the Scottish Silurians. The extraordinary faulting and consequent dislocation of the district makes it difficult to understand. Yet Dr. Lapworth has disentangled what to the physical geologist was a confused succession of limestones in detached masses, shales differing from but resembling each other, and conglomerates occurring in most tantalizing relations to them all; and out of the confusion he has succeeded in bringing method and arrangement. There are two Silurian areas—one north and the other south of the valley.

To the south lies a ridge stretching from the sea towards Barr, and this well-marked conglomerate forms a key to the district. Dipping below this conglomerate are shales with graptolites, shales with shells, and then a compact limestone. And wherever there is no faulting this succession can be made out. Next above these are found sandstone, shales, and thin shelly limestones. Many of these districts are fossiliferous, and in the cases are shewn specimens from nearly them all—graptolites, trilobites, shells, corals, &c.

Between the larger southern and the smaller northern area there lies the valley of the Girvan, formed of Carboniferous strata, and these are faulted on both sides against the Silurian rocks. The northern area is classic ground, for it has been visited by Sedgwick, Murchison, Miller, Lyell, Geikie, Nicholson, Etheridge, and many others. It consists of an anticline or dome—the highest part of the boss by denudation consisting of the lower rocks of

the series, and round it in elliptical zones are the encircling newer strata. It is in these encircling zones that fossils are found, and in some places they lie in lavish profusion and in beautiful preservation. There is one little spot—the very ideal of a geological picnic ground—sheltered by young odoriferous pine trees, carpeted with green soft moss and grass, having a "bare" of quarry debris 20ft high, with fragments lying at your feet crowded with Orthis, Leptaena, Strophomena, Rhynchonella, Murchisonia, &c., with Heliolites and other corals, and with fragments of Trilobites. What a place for a quiet day's finding! And when tired of the lavish profusion you leave this nook—"Rough Nook"—to find yourself on the winding road among what Hugh Miller called the "golden sandstones," and then gradually reach the summit of the gently sloping green ridge, where you pause to gaze on one side on the fertile valley and its dark woods and the gently sloping hills, on the other to the mirrored Firth of Clyde with Ailsa Craig rising majestically from the deep, and the Arran hills, and in the dim distance the Cantyre and Irish Coasts! What a wealth of vision, of philosophic thought, of health, comes to us!

> "Ah! that such beauty, varying in the light
> Of living nature, cannot be portrayed
> By words, nor by pencil's silent skill,
> But is the property of him alone
> Who hath beheld it, noted it with care,
> And in his mind recorded it with love."

Talk not to me of scientific knowledge lessening a man's appreciation of nature. To the geologist who notes the dislocations underlying the surface, the wondrous variations in the methodised plan, the unity and the variety of the design, to him in his lonely moments, and most fully when alone, comes a nearer approach to the Great Creator, a closer communion with Him, because a fuller appreciation of what He has so wondrously done.

B.—The Barr and Straiton Area.

To the north-east of this interesting area lies a district consisting of shales, flags, grits, and conglomerates. In a few localities fossils are found, and many of them evidently like those of the Upper Silurian areas of Muirkirk and Lesmahagow, to be noticed afterwards. South and east of this band from Girvan by Barr to Straiton lies a long stretch of southern uplands, with an interminable succession of upturned flagstones and shales, the order of which has not yet been determined.

C.—The Carsphairn Area.

As I had the pleasure of reading a paper to you on this district last year, I shall not transgress on your patience beyond

saying a few words to recall to you the grits with their accompanying graptolite beds, and the persistence with which these are associated for miles of the wildest mountain land. Let me also recall to your remembrance not only the contact metamorphism due to the two granitic "outblows" on each side of the Carsphairn area, but the metamorphism due more to flexure and contortion of strata, and productive of far greater mineralogical change. A word also needs to be said about this home of granite boulders, to be traced radiating from the district in all directions, and especially towards the shores of the Firth of Clyde and the Solway.

D.—The Lesmahagow Area.

This area consists of a long and comparatively narrow stretch of Upper Silurian rocks. The general strike of the beds corresponds generally with the long axis of the area from S.W. to N.E.; and the rocks seem to occupy an anticline of which Nutberry Hill is the highest ridge. To the south of this ridge the dip is irregular, and the rocks are faulted against the Old Red Sandstone and felspathic beds. But on the north side the Silurian rocks appear to be covered conformably by the Old Red Sandstone strata. This apparent conformability between the Upper Silurian and Old Red Sandstone is most interesting, and can be followed in some of the tributary streams quite plainly. It is remarkable also that the fossil forms so characteristic of this region—Pterygotus, Eurypterus, &c., are found in Forfarshire in beds that are indisputably of Old Red Sandstone age. It appears, therefore, both from *conformability* and from *fossil evidence* that the Lesmahagow are *transition* or passage beds between the Silurian below and the Old Red above. This district is somewhat difficult to reach but is full of interest, and in order to show you how careful one should be in regarding the geology of any locality *finished* I may tell you an incident. Many years ago I called on Dr. Slimon of Lesmahagow, the discoverer of these fossil remains, and asked him to give me any local information as to where they were found. He laughed at my hammers and chisels, and told me that Logan had to be quarried not hammered, and that he had so examined the district that little was left to find. *I* found little, although you have in one of the cases a complete set of the most characteristic fossils found in many lonely journeys. My friend, Dr. Hunter of Braidwood, tried the quarrying method, with the result that finer specimens were discovered and many new forms—one especially, the only specimen as yet of a fossil scorpion in British Silurian strata. For three months the enthusiastic Doctor and his hardy workmen lived in a tent, and midst storm and rain, and Scotch mist, dug their way into geological knowledge. The beds towards the narrower western end of the area

have a greater abundance of shell forms—Orthonota, Platyschisma, Modiolopsis, Lingula, &c., but the larger forms of Crustacea are not found, although the smaller, such as Ceratiocaris and Beyrichia are very common.

D.—The Silurians of the Pentlands.

Closely resembling in lithological nature and in fossils is the Pentland area. From lithological and fossil evidence the strata seem to represent both the Wenlock and Ludlow series. The Crustaceans—Slimonia, Beyrichia, Dictyocaris, &c., of the Lesmahagow and Muirkirk districts are found; but also some trilobites and shells that remind us more of the Girvan localities, such as Phacops Stokesii, Calymene Blumenbachii, Euomphalus rugosus, Bellerophon dilatatus, Atrypa reticularis, Orthis elegantula, &c. Indeed, this association of the representative fossils of two distinct English beds only points to the fact that in widely separated areas there may not be such marked separation, but rather gradual change from the one to the other.

E.—The Moffat Area.

It would be but an incomplete sketch of the Silurians of Southern Scotland if I did not, even at this late hour, dwell for a short time on the Moffat district. It is an elevated area drained by the head-waters of the Tweed, the Annan, Yarrow, Ettrick, and Clyde, and has such summits as Whitecombe (2,695ft.), and Hartfell (2,422ft.)

The district is occupied in the usual Silurian fashion by a succession of grits, greywackes, and shales, evidently occupying a series of anticlines and synclines. Denudation has laid bare the black shales, and the fossils found in them have enabled Professor Lapworth after years of persevering work to unravel the perplexing plications, inversions, and faults of the district. The strata seem to Professor Lapworth to indicate Lower Silurian formations—from Llandeilo to Lower Llandovery. The fossil evidence for the Moffat district consists mainly of graptolites which are found in extraordinary profusion in many localities. They have been grouped as Birkhill, Hartfell, and Glenkiln shales; and these sub-divisions are of much service in recognizing the horizons of other districts.

Summary.

Such is a rapid survey of this important formation, and in order to fix firmly the main points in your memory I would summarise the outstanding facts as follows:—

1. That this area may be regarded as a great dome or anticline, with its axis stretching from S.W. to N.E.
2. That this great anticline is flanked to the north and south by Upper Silurian rocks in the Lesmahagow and Pentland, and in the Eskdale districts.

3. That the *great* anticline includes many secondary anticlines, caused by the plication or folding of the rocks, and rendered in many cases perplexing by the consequent rupturing and faulting of the strata.
4. And that this confusion has been aggravated by the granitic outblows, throwing out some of the stratified rocks and altering others in every fashion of metamorphism.
5. That the sameness of the local colouring, and the monotony of the scenery, is due largely to the repetition of rocks of a uniform texture.
6. That the wilder nature of the western or Galloway part is due to the rougher character of the grits, and to the granitic upthrows.
7. That the denudation of this district has been so great that not only Upper Silurian and Old Red Sandstone have been swept away almost entirely from the central ridge; but there is every reason to believe that the areas covered by Carboniferous and Permian deposits were much more extensive than at present.
8. That much remains to be done over large areas of this country before it can be said that its geological history is complete. The great lines have been laid down, but there is ample room for individual and original work.

And need I conclude by saying that the district has many advantages? It is neglected by the ordinary tourist, and the people are as unconventional and as natural as the scenery and the soil. Your visit to these lonely solitudes may raise a question as to your object, or a wise shake of the head as to your mental condition, but a hearty welcome awaits you in shepherd's house, in farm, or in village inn. And if the problems are distracting, and their solution tantalising, they only keep you the more earnest in their pursuit. For fifteen years I have rambled among these glens and mountains, and I go back to them with all the zest of a schoolboy, and all the ardent affection of a first love. And many a professional care and worry is smoothed away by the thoughts of happy times and happy "finds," although the remembrances may be sobered by as many reminders of fruitless search and baffled ingenuity. There is no need in a gathering of "hammermen" to speak of our pure innocent joys, for I am certain the head of a trilobite, or the tail of a Pterygotus has raised more exciting aspirations than ever did the miser's treasures. Not "all the wealth of Ormuzd or of Jud" can compare with the wealth of lying on a sunlit hill with the victories of your hammer at your feet, and the satisfaction of conquest in your heart.

"How divine
The liberty, for frail, for mortal man
To roam at large among unpeopled glens
And mountainous retirements, only trod
By devious footsteps: regions consecrate
To oldest time! And reckless of the storm
That keeps the raven quiet in her nest,
Be as a presence or a motion—one
Among the many there."

An excellent collection of Silurian fossils, including graptolites, trilobites, corals, and crustaceans, was exhibited by Dr. Forsyth, and his paper was illustrated by numerous maps and diagrams.

In the discussion that followed Messrs. Carter, Groom, Kendall, and Walker took part. Dr. Forsyth answered several questions, and the proceedings closed with a vote of thanks to the lecturer.

Mr. John William Bond was elected an Associate of the Society.

FEBRUARY 15th, 1894.

Mr. JOHN INGLEBY, the President, in the Chair.

"THE RIO TINTO COPPER MINES."

By Mr. ROBERT H. WOOD, M.I.MECH.E.

(*Abstract*).

At the February meeting of the Leeds Geological Association, Mr. Robert H. Wood, M.I.Mech.E., exhibited an interesting collection of copper ores, and other minerals and fossils from the Rio Tinto Copper Mines and neighbourhood, and gave an account of the mining operations, and of the village and district generally. These mines are situated some 83 kilometres up the Rio Tinto from Huelva, and are said to have been originally worked by the Phœnicians and afterwards by the Romans, as Roman remains and relics have been found there. Some twenty years ago they were worked by the Spanish Government, but the operations resulted in an annual loss. English, Scottish, and some French capital, however, came to the rescue, and the mines were taken over by the present company with a capital of about seven and a half millions English money, and have been carried on ever since with marked energy and success. The company's large property includes a loading pier at the port of Huelva, and a line of railway following the Rio Tinto to the mines, besides some forty miles of rails within the mines, and the vast amount of powerful drilling, pumping, winding, and locomotive machinery necessary to such extensive operations. The output of mineral of all kinds has been

as much as 1,400,000 tons per annum, part of which is shipped as ore, but a greater proportion is dealt with on the spot, and the copper extracted by the burning method, which is found the cheapest and most productive. There are generally from 250,000 to 300,000 tons of ore in process of burning, in heaps of say 250 tons, covering a large area. This system is not without its drawbacks, and illustrates how the utilitarian needs of the age may be entirely destructive of scenic beauty and change the aspect of a whole district. The sulphur fumes have destroyed every vestige of vegetation over a considerable area. The extensive plateau west of the mining village, at one time pine covered, is now bare and bleak, and so powerful are the fumes that occasionally, when the wind blows from the burning ore, the miners have to abandon the village and go out of range until the wind changes. Continuous coughing, sneezing, and even bleeding of the nose are penalties of neglect of this precaution. The law of compensation, however, applies here, and the sulphur fumes have proved of great advantage from a sanitary point of view. Some fifteen years or so ago smallpox was very virulent at the mines, when one of the chiefs conceived the idea of placing heaps of burning mineral in the streets of the village. This acted so efficaciously as a disinfectant that the place was soon free from the terrible disease.

Mr. P. F. Kendall, F.G.S., exhibited a specimen of flexible micaceous sandstone from Nevada, and the theories advanced to account for its flexibility were in turn discussed; one theory ascribing it to the abundant presence of flexible mica, and another to the possible interlocking of acicular quartz crystals.

A hearty vote of thanks to Mr. Wood concluded the meeting.

MARCH 15th, 1894.

Mr. JOHN INGLEBY, the President, in the Chair.

Mr. P. F. Kendall, F.G.S., exhibited and described an interesting series of Cornish Pliocene Fossils.

"MOUNTAINS, VALLEYS, LAKES, AND FJORDS."

By Mr. THEO. T. GROOM, F.G.S.

(Abstract).

The lecturer began by stating that one of the first lessons the geologist had to learn was the great influence of denudation in modifying the surface of the earth. Every stream was doing its work in carving out the vale in which it ran, every frost helped to break up the rocks, and every breath of wind carried loosened particles away;

the sea, too, was steadily eating its way into the land. The general result of denudation was to carry materials from the higher levels and deposit them in lower. Great changes in the surface of the earth were thus effected. It had been calculated that if denudation were allowed free play, the surface of the earth would be reduced to the sea level in probably less than four million years. This we must suppose is a comparatively short time, geologically speaking. It followed that in order to preserve the balance of land and sea, which can be proved to have always held in geological times, movements of the crust of the earth, more especially movements of elevation, must have taken place. Proofs of the elevation or depression of large tracts of land were known many years ago, but it was only quite recently that geologists were coming to realise the great part that crust-movements had played in the history of the earth. The lecturer then pointed out how elevation or depression of a tract of land might modify the appearance of the earth. By upward or downward movement the land in a certain region would increase or diminish in size, and would in nearly all cases alter its shape; peninsulas might become islands, or, conversely, islands might be joined on to the main land. Such changes were, of course, most easily estimated along coasts, where terraces, raised beaches, sunken houses, forests, or reefs afforded the necessary proofs. An interesting case of local elevation was seen in the region of the great lakes in Canada. It had been proved that formerly the site of the lakes was occupied by a system of great valleys; local elevation in parts of the area had resulted in the production of a series of great lakes from portions of the valleys. Much more important and extensive was the elevation of tracts of land along certain lines. This resulted in the production of great ranges of mountains. Most of the great mountain-chains of the world could be proved to be due to this process. The beds composing the crust of the earth in these regions had evidently been subjected to great pressure, and had accordingly been arched up and thrown into folds. In many cases the pressure had been so powerful that folds, or fractured portions of folds, had been piled up on one another. The great chains of mountains constituting the Pyrenees, the Alps, the Himalayas, and other ranges showed this structure. Very interesting were the basal wrecks of old mountain-chains, which had formerly diversified Europe. One of these ran all down Norway, across the site of the North Sea into Scotland, North England, and Ireland. Scotland might be described as an isolated portion of this old "Caledonian" range, the upper and greater part of which had been denuded away. A second of these great ranges, the "Armorican," ran from Central France across the Channel into South England, South Wales, and Ireland. A part

of this old fossil range lay denuded and buried beneath London, and might be expected to furnish coal for the metropolis before very long. A third great range ran from Central France into Belgium, Germany, and Austria. Many of the most beautiful regions in these countries, such as the Ardennes, the Vosges, the Black Forest, and the Hartz Mountains, were wrecks of this "Variscan" range. The existing group of the Henry Mountains in the Western States of America were next described as the sole example known of a very different type of mountain structure, produced by the intrusion of lenticular masses of lava between the beds, which were accordingly raised in a blister-like manner. The high land on which this small group of mountains was situated formed a high-plateau region, and was exceedingly instructive from a geological point of view. The beds were mostly horizontal, but the whole region was divided by faults into blocks at different levels; the higher blocks formed mountains, the lower valleys, whilst the actual faults formed cliffs. In the "Great Basin" to the west of the plateaux a somewhat similar structure was seen, but the separate blocks were often tilted. The tilted blocks often formed peculiar short ranges of mountains; the depressed ones were occupied by valleys and lakes. Many lakes in this and neighbouring regions were, then, due to the actual depression of the earth's surface, and not to elevations of barriers across valleys, as in the case of the Canadian lakes. Mr. Groom then contrasted the conditions obtaining in the western part of the United States with those seen in Great Britain. Examples of surfaces directly due to earth movement were absent for several reasons. The movements which had affected the rocks of Great Britain were very ancient, and most of the inequalities produced by faulting and folding had long since been obliterated by denudation, which, owing to the climatic conditions, could act with full effect. In the plateau region of Utah, and in the neighbouring districts, the movements, on the other hand, were of comparatively recent occurrence; they were, in fact, almost certainly still going on. The region had not been submerged beneath the sea since Cretaceous times, and sub-aërial denudation was slow, and mainly limited to the actual water channels. It resulted, then, that the chief features of the land in this region were determined by geological movements. The lecturer next referred to the fjords of Norway as due mainly to the faulting down of blocks which, as in the Basin ranges, were tilted. Here, however, denudation had greatly obscured the original structure. The Dead Sea and Valley of the Jordan showed a similar origin, and the same might be said of many other areas. Finally, it was pointed out, the consideration of the origin of the more local features leads by easy passages to that of the larger, such as that of the "Great Basin"

itself. There could be little doubt that this depression was due to actual sinking of the crust, and there was much evidence that still more extended regions of relative elevation or depression, whether above the sea or not, were due to similar movements. The magnificent work done by the American, Continental, and British geologists of later years tended clearly, it was maintained, to throw doubt upon the theory of "the permanence of continents and ocean basins," and to establish the view that not only many of the minor, but most of the major features of the earth's surface are due to movements of the crust.

Mr. Groom's lecture was illustrated by an admirable series of lantern slides.

A discussion followed, in which the Rev. W. L. Carter, M.A., F.G.S., and Messrs. J. H. Howarth, F.G.S., P. F. Kendall, F.G.S., W. Teasdale, F.R.M.S., and G. D. Patterson took part, concluding with a hearty vote of thanks to the lecturer and Mr. Kendall.

APRIL 19th, 1894.

Mr. JOHN INGLEBY, the President, in the Chair.

Mr. J. H. Howarth, F.G.S., exhibited and described a series of Carboniferous Limestone fossils. Mr. John W. Bond exhibited a very fine specimen of Lepidostrobus from Burmantofts, and Mr. P. F. Kendall, F.G.S., a piece of recrystallized sandstone.

"THE ANCIENT AND MODERN GLACIERS OF NORTH AMERICA."

By Mr. PERCY F. KENDALL, F.G.S.

(Abstract).

The lecturer stated that the series of lantern slides which he purposed shewing was furnished to him by the kindness of Prof. G. F. Wright, of Oberlin. He stated that the subject of the phenomena of the ancient glaciers of the North American Continent, and of those immense ice-rivers which at present descend to the sea from the Cordilleran Range in Alaska, had a special interest to English geologists on account, first, of the enormous scale upon which they were developed, and secondly, because so vast an area of the North American Continent was occupied by glacial deposits, that American geologists had been compelled to make such a systematic study of the causes and effects of the glaciation of their country, that they had been enabled to discover entirely new methods of research announced to the Old World, with the result that the first attempt to bring the glacial geology of the British Isles within one complete and comprehensive scheme

was made by a distinguished American geologist no longer with us, and the same office was performed for North Germany by Prof. Salisbury. English geologists have been too prone to limit their critical studies of glacial action to the comparatively small and steep glaciers of the Alps and of Norway, and thus, as has been pointed out, have fallen into the error of one who should from a study of mountain torrents attempt to establish their behaviour as criteria by which to judge the action of slow-moving rivers in the lowlands.

The first pictures shewn represented different aspects of the great Muir Glacier of Alaska, and amongst noteworthy features displayed were sections in which the sides of the glacier were seen to rest upon a series of stratified sands and gravels, over which the ice, during recent extensions of the glacier, had passed without disturbing the bedding of these loose deposits. In one view the sands and gravels were seen to lie bedded between the erect trunks of a forest of cedars, and were so placed as to leave no room for doubt that the vast body of ice had actually passed over these trees and the beds which surround them without disturbing the one or the other, an interesting and valuable confirmation of the opinions expressed by some English geologists regarding the possibility of glacier-ice moving over soft materials without either disturbing or eroding them.

Another picture from a negative taken by Prof. Israel C. Russell showed a dense pine forest consisting of trees three feet or more in diameter standing and growing upon the surface of the great Malaspina Glacier (Mount St. Elias), at a distance of five miles from its terminal front, and with at least 1,000 feet vertical thickness of moving ice beneath it.

The lecturer said that this glacier was exceptional for the vast quantity of morainic material which it bore upon its surface, and in which these trees were rooted. Local melting of superficial portions of the ice cause movements from time to time of the moraine stuff, revealing bare knobs of ice. These, in their turn, being exposed to the sun would melt, causing a depression into which the rubbish would slide.

A map of the North American Continent, showing the direction of ice-movement, the extent of the glaciated area, and the position of the successive terminal moraines laid down by the great ice-cap was shewn, and attention was directed to the singular driftless area of Wisconsin, a region which, though destitute of drift deposits, was nevertheless in the glacial period completely surrounded by ice. The explanation of this singular phenomenon adopted by American geologists was mentioned, viz.: that two lobes of the great ice-sheet emerging respectively from the deep hollows of Lake Superior and Lake Michigan, did not coalesce

until they had passed to the southward of Wisconsin. Furthermore, the region was probably in the glacial period, as now, one of exceedingly low precipitation. A large number of views were shewn illustrating some of the more remarkable features of scenery produced by the glacial deposits, and also sections shewing typical or abnormal developments of the deposits and other evidences of ice, such as the remarkable glacial grooves and flutings on Kelley Island, Lake Erie, which have been secured from destruction and are held in trust by the Western Reserve Historical Society of Cleveland, Ohio. A number of pictures were shewn illustrating the remarkable features of the volcanic region of the Snake River and the lava plains of Idaho. These the lecturer said might appear to have but little connection with the subject of his lecture, but American geologists had endeavoured to establish a connection between these vast volcanic outpourings which flooded so enormous an area in the district named, with the glaciation of the Eastern States, either as cause or as effect. Thus Prof. Winchell has supposed that the imposition of this load of a mile thickness of ice over an area of 1,000,000 square miles in the Eastern and Central States acted upon a supposititious liquid or molten substratum of the earth's crust, so as to force it out along the margin of the ice-sheet. Prof. Bailey, on the other hand, regarded the extrusion of the stupendous lava floods as a cause (at least a partial cause) rather than as an effect of the glaciation of the Eastern States. He considers that the effect of these great igneous outpourings would be to maintain the temperature of the moist westerly winds blowing over the Cordilleran Chain and thus prevent the precipitation of the water which they carried until they reached the great central valley, where condensation would take place in the form of snow augmenting the ice-load in that region.

The lecturer then proceeded to illustrate with another series of views, some of the evidence which has been brought forward by American geologists to determine, if possible, the date of the glacial period. After a brief allusion to the estimates of post-glacial time which have been based upon the observed rate of accumulation of blown sand on the shores of the great lakes, and upon the estimated rate of the in-filling of kettle-holes, the lecturer discussed the evidence afforded by the rate of recent recession of the Falls of St. Anthony at Minneapolis, which, assuming the uniform rate to have been maintained since the retreat of the ice, indicated the lapse of about 7,800 years since that event.

Coming to the case of the Niagara Falls, which was illustrated by a large series of views and maps, together with plans of the surface surveys, from the first, that made in 1842 at the instigation

of Sir Chas. Lyell, he showed that the average rate of recession of the crest of the Horse-Shoe Fall during the period covered by these surveys was about two feet six inches per annum, a result in remarkable accord with the estimate of Mr. Robert Bakewell in the early part of the century. The total length of the Niagara gorge, between the Falls and Queenstown, is between six and seven miles, and if the present rate of recession had been maintained, the time required for its formation would be about 14,000 years, but there are many circumstances which seem to justify the conclusion that during a long period the rate of cutting was greatly in excess of this estimate, and that 7,000 years would be a more accurate estimate of the time required for the whole operation.

It was, until recently, supposed that directly the southern front of the great ice-sheet had retreated to the region of the great lakes, the whole drainage of that vast region would, as now, pass through the Niagara Valley, but a series of remarkable observations made within the last two years by Prof. G. F. Wright, shews that this was not the case. The region of the great lakes has been, and perhaps is now, one of exceptional and rapid earth movement. A post-glacial elevation in the valley of the St. Lawrence, to the extent of upwards of 500 feet, is known to have taken place, and existing levels are so critical, and many of the watersheds are so low, that comparatively slight changes of level mould produce altogether disproportionate effects upon the drainage of the country. Thus a ridge only 25 feet in height intervenes at Chicago between Lake Michigan and the head waters of the Ohio, and the municipal authorities of Chicago are at present carrying out a scheme for cutting through the ridge and abstracting water sufficient to produce a large river flowing down from the lake into the Mississippi basin, and acting as a vehicle for the drainage of their city. This illustrates one of the possible directions in which the surplus waters, or a portion of them, from the great lakes may have made their way seawards, avoiding Niagara altogether, but Prof. Wright's most important discoveries relate to an entirely different route, which he has shewn did actually carry off a vast quantity, if not the whole, of the drainage. Lake Nipissing drains into Lake Huron, on the north side, and there is a difference of 70 feet only in their surface levels: Lake Nipissing is separated from Trout Lake by a tract of swampy ground three miles in breadth, and only 25 feet above the level of the two lakes, and Trout Lake is drained by the Mattawan, a tributary of the Ottawa, which in its turn flows into the St. Lawrence, at Montreal, many miles below Niagara. Now, Prof. Wright has discovered a clearly defined river channel extending from Lake Nipissing to Trout Lake, with

great river terraces of well-rounded gravel making a shore line as well defined as that of the Niagara River above the Falls. This channel can be followed down the Mattawan to its confluence with the Ottawa, where, as usual at the confluence of a rapid stream with a more sluggish one, a vast accumulation of gravel and large boulders can be seen. Prof. Wright has thus shewn that the great lakes had a post-glacial outlet in a river of large dimensions, which may have performed all the functions which subsequently devolved upon the Niagara, and so proving that the recession of the Niagara Falls cannot be accepted as a satisfactory chronometer by which to measure the duration of post-glacial time.

It is right that I should point out that observations made by Mr. F. B. Taylor (see *American Geologist*, May and June, 1894, and *Glacialists' Magazine*, Vol. I., p. 253), strongly favour the supposition that during the whole time when the Nipissing Channel was open, the margin of the great ice-sheet was near at hand. It would follow, therefore, that this outlet belonged to the Glacial Period, and its existence would not invalidate the measurement of Post Glacial time by the rate of recession of the Niagara Falls. I would also remark that this recent work of Mr. Taylor appears to necessitate a reconsideration of many problems connected with supposed differential movements in the neighbourhood of the Great Lakes. P.F.K.

MAY 24th, 1894.

Mr. JOHN INGLEBY, the President, in the Chair.

A fine collection of interesting forms of silica, including agates, chalcedonies, crystals, and fossils in flint, was exhibited and described by Mr. C. D. Hardcastle.

"NOTES ON A TRIP TO NORWAY,"

By Mr. DAVID FORSYTH, M.A., D.Sc.

It is not my intention to write a detailed description of a trip after the plan of a diary with each day's incidents; but to place before you my impressions of a first visit to Norway, and generally to tell you how its scenery and people struck a stranger. Leaving out of mention the journey from Leith to Aberdeen and across the German Ocean, I begin at once with "Norway and the Norwegians."

The outer fringe of islands and fiords on our approach to Stavanger were to me, after many memorable visits to the western districts of Scotland, somewhat disappointing. In everything except the wooden houses with their gay colourings, and the shape of the boats with their upturned prows that needed only a

carved raven or kraken to remind us of the old Vikings, it was like approaching the western shores of Ross or Inverness. It is when the traveller by means of the wondrous fiords gets far inland, or takes an inland trip by the excellent road-routes, that the real majesty of Norwegian scenery is experienced. While, therefore, I have nothing but praise to utter regarding the attention and skill of all the officials of the ship, I would advise all who have any intention of going to Norway to be sure to avail themselves of the facilities of the inland trips. Our "floating home" was all the more esteemed after the short flights we took into strange parts, and its good Scotch fare was occasionally a welcome change from foreign diet.

The outlying islands form an almost continuous barrier, breaking the force of the ocean waves, and making the navigation pleasant even to the most sensitive subjects of sea-sickness. Our experience in this matter was almost unique. In crossing from Aberdeen to Stavanger there wasn't a ripple that would have been unusual on Roundhay Lake; nor in our coasting voyage, except in rounding Stadtland, was there a "roll." On our return the woe-be-gone countenances of the passengers of the sister ship, the St. Sunniva, told another tale, for of 80 passengers crossing *only four* had the courage of mind, or rather of stomach, to sit down to dinner.

At Stavanger there was one building specially worth visiting, the Cathedral. Although long after church hours the keeper opened the doors and soon lit up the building for our gratification. The great heavy pillars and the small windows gave a gloomy impression to the visitors, but suggested massive strength and stability. The wooden pulpit with its ornate carvings, often of a rude type, and its gaudy colouring formed quite a contrast, not altogether in keeping with the tone of the interior. The old watch-tower with its arrangements for intimating quickly the outbreak of the dreaded enemy, fire, impressed one with the need for such precautions in a *wooden* town. Might I also here give expression to an impression then formed, and afterwards strengthened by more observation, as to the temperate character of the people. Sunday afternoon is the great time for excursions, games, band-playing, etc., and the absence of drunkenness was remarkable. While the courtesy of ordinary working-men and peasants to one another was a lesson in itself. It betokened nothing of servility, but much of kindly feeling, and of self-respect.

A trip up the Bukke Fiord took us to Sand, where we disembarked for our first inland trip. What an array of vehicles awaited us! *Carriages* for four, *stolkjarres* for two, and *carrioles* for one! Following the strict scriptural injunction we two were not separated, but in our stolkjarre with a spirited pony were soon

trotting into Norway. We did, however, have one division of opinion, for while I exercised my skill (?) in selecting a steed, my wife always picked out a driver who, from some bodily defect, seemed most in need of a fare. Our first one was lame; and our second was hump-backed, and his name was *Odd*, and his horse was *Blok*. The scanty cultivation, the utilisation of every fertile nook, the careful gathering of every blade of grass for hay, at once indicated a thrifty, hard-working race, whom fate had placed in stern conflict with a niggardly nature and an extreme climate:—a stolid, if not a sad race, who took even their pleasures sadly, with patient wondering eyes and unsmiling faces looking at the gay laughing tourists who sped along their upland roads. And yet a merry lot were our young drivers—helpful, happy, musical too—singing such airs as gladdened the hearts of the Englishmen, "Home, Sweet Home," and "God save the Queen." While the steeper parts of our journeys often compelled a walking pace, and the hammer and the vasculum were busy. Gneiss, granite, and what looked like Silurian shales much altered, were my first finds; and the flora was much the same as that of our own moors. Potentilla tormentilla gemmed with its yellow blossom every roadside, and Vaccinium myrtillus (the bilberry) was in extraordinary profusion; while the trees around were those of Airedale and Wharfedale.

The Suldal Lake has all the look to me of some of our West Highland lakes like Loch Shiel and Loch Maree—*inland glacier lakes* gouged out by the glaciers in their downward course towards the fiords, which are the "*sea* rock basins" chiselled out by the same mighty agent. The steep precipice opposite the little landing stage, where the little steamer awaited us, was a remnant of geological agency—upturned Silurian shale, and glacial action along the line of its outcrop. While on the same route, after landing at the head of the lake and enjoying thoroughly our first Norwegian luncheon, the picturesque ravine with its overhanging cliffs towering above us, and threatening at times to fall and crush the intruders, and the narrow path guarded (?) by a few blocks of granite at wide intervals, giving a kind of illusory notion of a boundary line between us and the precipice beneath, and far below the rushing, whirling, eddying, tumbling, gray-green, glacier-fed torrent that comes thundering down to find its resting place and depositing-station in the calm lake, were scenes ever to be remembered. The finely disintegrated sediment by reflection and refraction imparts the peculiar colour so characteristic of glacier-fed streams, varying from grey-white, grey-green, greenish-blue, to intense blue in the still pools, but yet not a clear limpid blue, but a blue giving you an impression that flake-white had been mixed with the cobalt, imparting

just a suspicion of opacity. I found this colour quite a test of the origin of the Norwegian rivers; for if the lovely shades of raw sienna, brown umber, prevail, I recognised at once the ordinary English or Scottish type, free from glacial sediment; if greenish or bluish their home was the glacier—the Folgefonde above us, of which now and again we had a peep, telling us whence the mighty flow was due of such short streams. The whole of this route was full of interest. At the Suldal end of the ravine I found a thick intrusive mass of greenstone lying almost horizontal with granite below and granite above. And the winding road above the ruin skirting a smaller lake was like a drive in the Highlands, while the welcome refreshment and rest at Breifond's Hotel soon made me equal to a quiet evening stroll to the beginning of Roldal. What a panorama of glens, and peaks blushing under the tints of the setting sun, and the intense shadowy gloom of the valleys blue-black below because shut out from the sun's after-glow! Next morning we were up with the sun, but if the early bird usually gets the worm, our case was exceptional, for with a slumbering household what could you expect for breakfast at five a.m.? But what a morning! Behind us lay the sleeping hamlet, for even the hardy Norseman was not astir, and the calm lake reflected no sail. While high above the peaks were glowing in the sun, and the snowfield glistening white with that ever-startling tint unknown to us here in summer rambles. Up the winding pass climbed the sturdy horse, but as the road was most serpentine I took to the hill-side and clambered to the summit of the ridge. The summit of the Horrabraken is 3,400 feet above the sea, and quite near the road I found snow lying, with which I pelted my long-suffering companion; while up on a cliff the haymakers screamed their appreciation of the small practical joke. The downward course is quite as interesting, and the footing quite as difficult, but these hardy ponies seem to be made of a compound of animated india-rubber and steel, for no matter how long the journey the last five miles can be done at quick speed. Satiated as one becomes with waterfalls, yet in this dale there are three, all different in style and all worthy a visit—Lotefos, Skarsfos, Espelandsfos. But the greatest treat to me was the trip to the Buarbrae glacier. As an educational object lesson it was something to be for ever remembered, the streaky flow resembling at a distance the "ropiness" of sugar, the wonderful colouring intense blue in the hollows and crevasses, pink or rose red where the slanting sun struck the projections, or pure white as the level parts of the glacier extended without prominence or fall. One could see *the flow* in its evident forms, its power in the moraine blocks, and its results in the turbid stream. Despite the warnings up I clambered its sides among moraine dirt and

crinkling ice, till I reached a projection where I could at least see the great Folgefonde névé, the birthplace of the ice-stream beneath my feet. I could have spent a day poking about among its corners chipping the debris or exploring the dangerous ice-caves, but a forlorn lady waited for me by the lake, in dire distress lest the boat should depart and leave the partner of her joys stranded in Buarbrae, and I tore myself from the enticing prospect. The potato and rye fields, within a stone throw of the terminal moraine, with their red, green, and yellow tinge, were a contrast to the ice and snow so near. While on the way back I was amused with the way in which hay, brushwood, and firewood are conveyed from the terraces of the mountain to the valley beneath, by means of a stretched wire. The rocks in the moraine were granite, gneiss, metamorphosed shale, and presented no extraordinary features. From Odde the sail down the Hardanger Fiord was, in the summer evening and afterwards in the moonlight, a succession of surprises, of awe-striking precipices, of cottages perched on impossible heights, of majestic solitudes saved from becoming appalling by the gladsome sound of the river or the cataract, and by the throbbing of our propeller.

Bergen, with its fish-scented air and its odd conjunction of rural and town life in its market-place, has a museum worthy of every scientific man's attention. In marine zoology I have never seen anything to equal the variety of forms, large and small, and the varying arrangements—sometimes on a commercial basis—representing sea products and their processes of manufacture; and at another severely scientific Geology found its proper position on the basement with a fair representation of minerals, but with few fossils. I suspect that the commercial importance of the sea and its products to Bergen dwarfs the cultivation of geological study.

The run by rail from Bergen to Vossevangen through a constant succession of tunnels, with its gentle speed enabling one to see the main features of the landscape and the variety of the scenery as the line now skirts a lake, now a steep precipitous valley, and at another time runs into a broadening valley with the usual types of Norwegian homesteads and tiny patches of cultivated grounds, formed quite an interesting feature of the first part of our second inland trip. The drive from Vossevangen to Stalheim is through a well-cultivated district, narrowing as it approaches the mountains, but all its variety was dwarfed in comparison with the view from Stalheim into the head of Naerodal Pass. Straight before us rose a mountain of grey disintegrating granite, almost conical in shape, and its sides "floured" as it were with kaolin, and in the background the hills as I saw them, purple black from a passing shower, while a fleecy mist gradually

afterwards lifted and gave way to the glimpses of the white snow; while quite near us in the foreground were two waterfalls to right and left, Stalheimfos and Scolefos. At times the pass was so sublimely picturesque that we hesitated to speak except in whispers. Without exception the finest mountain drive I have ever seen!

Time only allows me to mention the Geiranger Fiord with its steep cliffs, "the Seven Sisters," and other waterfalls.

Above Romsdal there was a splendid example of a post-glacial terrace shot out from a side stream, and at one time covering up a terminal moraine and damming back a glacial lake. But the gathering waters had gradually worn a channel in the gravel mound; and the moraine lay exposed below, the contrast between the gravel "kaim" and the tough glacial boulder clay being as marked as if it had been made yesterday. And what a pleasure that "carriole" trip up the glen was! for emboldened by past experiences we were now acting as independent drivers, and the Norwegian air was fast acclimatising us to Norwegian ways. Molde lives in my memory from two things:—(1) The magnificent panorama of gulf, strait, headland, island; one wished for a month's exploration of its nooks; and (2) from the saddening visit I paid to the leper house, whose sad sights ever form in my mind a kind of background of sorrow to a sunny trip. Diet has had, I believe, much to do with this sad visitation; but government action has done much to *isolate* and therefore to diminish the evil. I was told that of the thousands whom this terrible disease afflicted ten years ago, there are only 700 lepers in Norway now. Notification of disease, and compulsory isolation combined with kindly treatment and medical skill are doing much to remove the plague spot.

At Trondjheim we spent a Sunday like good Leeds citizens, by first going to the Cathedral service where religious worship had to be performed without any intelligent understanding of the divine's sermon. A military band and national sports supplied the Continental element; and although the canny Norwegians did not *open* their shops the blinds were not drawn down, and to many establishments there were convenient *side* or *back* doors for capturing the purchasing English tourists.

On our way back the navigation was remarkably clever through quite a series of tortuous passages, marked in a most primitive fashion. One evening we anchored in a lonely bay begirt with islands, and although quite near to land the ship had to let out 150 fathoms of chain.

From the accompanying slides you have had a rapid glance at a magnificent land, "a land of mountain and of flood," within easy reach and not expensive. To the jaded man of business, to

the harassed teacher, to all students of nature, to the botanist, to the photographer, to the inquisitive geologist, to the double, to the single, to the young, to the old, seeking for a rest, for a change, for variety, for happiness, for good fellowship, for sunny memories, I say take a trip to Norway.

"ON WHEELS IN NORWAY,"

BY MR. S. W. CUTTRISS.

We left Newcastle-on-Tyne on Thursday evening, August 17th, 1893, and arrived at Stavanger on Saturday morning about 8 a.m., weather dull with threatening rain. This is one of the principal and most ancient towns in Norway. It has suffered frequently from fire and many of the houses now being built of stone it presents quite a modern appearance. Fishing is the principal industry. About 10 a.m. we cast off and steamed up the coast between the numerous islands. The mountains nowhere rise to a great height, and many of the islands being bare rock or sparsely covered with vegetation, the landscape presents rather a forbidding aspect. We had a Norwegian pilot on board, and it was surprising to watch how dexterously he navigated the vessel through the narrow and often dangerous channels. One cannot but admire their seamanship when it is remembered that they navigate these waters at night as well as day. It was dark when Bergen was reached, about nine o'clock. The custom officers were very lenient and did not even look at my luggage. Bergen is picturesquely situated on a hilly peninsula, and the surrounding mountains rise to about 2,000 feet. The climate is said to be exceedingly mild and humid, the thermometer in winter rarely falling below 15°-20° F., and the frosts being of short duration. The modern portion of the town is built of stone, but the older parts consist of closely built wooden houses painted white and red tiled roofs. From time immemorial Bergen has been the fish market of Norway. Cod, herring, oysters, and lobsters being the principal fish exported. English is spoken very generally.

Sunday morning was spent in a general tour of the town, including a visit to the museum, containing a valuable and interesting antiquarian collection. The Hanseatic museum was also visited. This was specially interesting as illustrating the way the gaards or warehouses of the old Hanseatic merchants were fitted up. The remains of only a few of these are now extant. About 4 p.m. I was in the station waiting for the train to start for Vossevangen (Voss). This is a narrow guage, single line railway, running between Bergen and Voss. The line is about 66 miles long, or 9½ Norsk miles, and has 52 tunnels, the longest of which is about three-quarters of a mile long. The

carriages are built on the corridor plan, and are second and third classes only. The journey takes about 4½ hours to complete, a stop of about ten or fifteen minutes being made at every station. Everything is done in a leisurely manner, which is characteristic of the race; they have no cause to hurry.

The scenery throughout is very fine, the line in many places being cut out of the mountain side over-hanging the water below. Being Sunday, all the stations are filled with idlers, and the native costume of the girls looked very effective. When the train moved off from a station there was a great waving of hands and many "farvels." Rain had been threatening all day, and before the journey was completed it began to fall in heavy showers.

The rain continued to fall more or less all night; but in the morning the weather shewed signs of clearing. After a scramble up the hill to get a few geological specimens, I mounted my bicycle for the first time in Norway en route for Eide. The road leads in a S.E. direction skirting the Vosse-elv, and rises with an easy gradient for seven miles to its highest point,

The roads, except in the neighbourhood of the large towns, are made with gravel, which gives a beautiful, smooth surface when dry and hard, but when cut up or thoroughly wet they are very bad for cycling. "Baedeker" describes this part of the country as "pretty and well cultivated, but somewhat monotonous." Compared with many parts of Norway this is correct, but even then it is far grander than anything to be seen in England, the surrounding mountains rising to over 3,000 and 4,000 feet, and in many places snow-capped although so late in the summer. From the summit the road gradually descends until the upper part of the valley terminates suddenly, and then it descends in zigzags into the picturesque valley of Skjervet, flanked on either side with high mountains and imposing precipices. The road crosses the river between the upper and lower Skjervefos and descends 500 feet in about ¾ mile. Continuing by an easy descent, the road skirts the Gravens-vand, then through a rocky defile and on to Eide, at the head of the Graven-fjord. From here the steamer has to be taken for Odde, at the head of the Sor-fjord. Odde is at the terminus of the overland route to Christiania through the Telemarken. There is nothing of particular interest in the village itself, but it forms a convenient centre for several interesting excursions.

The following morning the weather was anything but encouraging, a strong wind blowing, accompanied by heavy rain showers. However, having come this route specially with a view of visiting the Buar-brae glacier, I was not going to be put off by disagreeable weather. About 7.30 I started on foot from

the hotel for a day on the mountains. Following up the river in a southerly direction in about half-an-hour I arrived at the Sandvenvand. This lake is caused by the terminal moraine of an old glacier blocking up the valley, the dammed up water having subsequently cut a passage through on the east side, from whence it descends in a fine series of rapids to the sea below. The river which flows down the valley from the glacier was a very fine sight, being in flood and over the path in many places. I could distinctly hear the rocks being rolled down the river bed. The ascent to the foot of the glacier, about 1½ hour's walk, is very easy; a good path all the way. The valley or gorge is cut deep into the mountains and is very picturesque, barley and well-developed trees growing right up to the foot of the glacier, which is about 1,100 feet above the sea. My attention was attracted by thick wires stretched from the bottom of the valley to high up the mountain side, and sometimes across the river. These, I found, are used for the purpose of conveying the hay from the mountains to the valley, it being attached and shot down to the bottom. Apparently anything that the sickle will cut through is gathered for hay, good grass being scarce. It is interesting to note how the river is pushing its delta far into the lake, the water being heavily laden with mud from the glacier.

The Buar-brae has its origin in the Folgefond a large snow field; about 23 miles long and from 3 to 9 miles wide. It covers a plateau of from 3,000 to 5,000 feet high, situated between the Hardanger and Sor Fjords. The mountains attain their greatest height, 5,425 feet, immediately to the west of the Sor-fjord, and the snow plateau descends gradually to the W. The snowfield gives off several glaciers, of which the Buarbrae is the easiest accessible from Odde, although I believe it is not the finest. The view from the foot of the glacier is very fine. High above can be seen the edge of the snowfield, all rugged and broken up. As the fall of ice descends the steep declivity it is divided into two branches by a ridge of rock, the branches again uniting lower down and contracting in width as the sides of the mountains approach each other. The surface is strewn with rocks and debris which form a central moraine, and when this is seen close to I must confess it spoils the artistic effect, making the ice look very dirty. The temperature of the water as it issued from under the ice was found to be 36½ deg. F. This, probably, was a little higher than usual, owing to the flood water with which it was mixed. Leaving the glacier I ascended the mountain to the right to a height of 4,200 feet. As the weather was very bad I decided to return instead of continuing up to the Folgefond. The wind was specially trying at the top of the steepest part of the ascent near the cairn, and I had to discard my waterproof

cape as it was continually blown over my head. When at the highest elevation I caught sight of a valley beyond, and was very vexed afterwards at having turned back, as I subsequently found I could have descended by it and returned to Odde by another route. By the time I had reached the Sandvenvand again the weather had considerably improved and the water was much smoother. A flag is kept at the gaard for signalling to the boatman, but not knowing this a quarter of an hour was spent in ineffectual signalling with handkerchief tied on end of stick, and a pocket whistle. I was just starting to walk over the rocks when a man appeared and offered by signs to show me the way. I was very glad I did return by land as some splendid examples of glacial grooving were seen on the route. From Odde the route lay along the east side of the Sandvenvand, already mentioned, passing the Kjondalsfos on the left and the Strandsfos on the opposite side of the lake. Waterfalls are such an ever present feature of the landscape that it would be tedious to mention all that were seen, so I will only refer to the finest examples passed. Leaving the lake, the road continues practically level for seven miles from Odde. The valley then contracts into a narrow ravine down which the river rushes in a foaming torrent, and the road begins to rise. Two miles further the Lotefos and Skarsfos are reached. The two falls are close to the road and form the most impressive falls seen throughout the journey. The spray is driven in a dense cloud across the road, against which an umbrella is of little use. Past the falls the road continued to rise steadily, and ultimately developed into a long series of zigzags through magnificent scenery, being cut in many places out of the bare rock high up the side of deep and wide gorges. After nearly three hours steady work, a halt was made at the Seljestad saeter, a wayside inn where horses are usually changed for the remainder of the ascent; a highly necessary proceeding for anyone driving. Seljestad is sixteen miles from Odde, 2,070 feet high, and is situated in a comparatively flat and lonely valley, forming a break in the ascent. The scenery now changed, assuming a bleak and desolate aspect; the mountains in great part being bare rock or thinly covered with vegetation, all trees having been left behind.

Soon after leaving Seljestad the road again ascends by zigzags until the summit is reached. The pass is 3,392 feet high. Distance from Seljestad 4½ miles, this makes 11½ miles practically all uphill and mostly walking. In describing the route Baedeker says "the scene is one of the finest and most characteristic in Norway;" it certainly surpassed anything I had seen before. The road now led along a lonely ridge and then descended in continuous windings to the Roldalsvand, 5½ miles, then nearly

level to Roldal, two miles, 1,300 feet.

The road throughout is splendidly engineered, the gradients nowhere being excessive, and the surface good. A characteristic feature of the Norsk road is the slight protection at the sides, no wall or fencing, only large boulders about three feet apart, even where the road is on the edge of a precipice or above water. The machine was a great attraction to the dogs, which raced after it for long distances, barking furiously. Referring to the roads, they would be disappointing to the "scorcher" as a high speed cannot be attained owing to the constant sharp bends, and narrow width, which make the danger of a collision with passing vehicles very probable.

The following morning a fairly early start was made as more climbing had to be done to cross the pass of Dyreskard over the watershed of the mountains. A long detour is made to skirt a spur of the mountain, then the road gradually ascends for 3½ miles to 2,140 feet, following which is another long series of windings rising to 3,400 feet. The scenery is now different from anything previously seen. Instead of deep gorges and precipitous mountains towering far above, the high elevation of the road gives a view of the summits of the mountains, and their rounded tops reminded me forcibly of the Scottish Highlands. From this point it is a gradual and easy ascent to the top of the pass 3,715 feet (another 3½ miles). This is considerably higher than any mountain in England or Wales, and is only exceeded by a few in Scotland. I thus beat the previous day's record by 300 feet, and it is the highest level I have yet attained with a bicycle. Soon after commencing the descent I came upon a number of workmen, at a turn in the road, engaged constructing a tunnel in the mountain side parallel with the road. This is for protection from the avalanches which descend from the heights above, and completely block the road. Even at this late season of the year there was considerable snow, and in spring it must be a very dangerous corner. An easy run down for eight miles brought me to the Haukeli saeter, 3,280 feet, where a good dinner was obtained.

The solitary fjeld scenery is here seen to full advantage. This is aproximately the limit of elevation of shrub growth, and fir trees do not appear until about 900 feet lower. Here I made my acquaintance with "multer," a berry of which the Norwegians are very proud, very similar in size and shape to the blackberry, but yellow in colour and very pleasant to the taste. About two o'clock I remounted and continued downhill passing Botten saeter, to the junction of the Flaathol and Geislaus elves. Fancy 27 miles downhill almost without a break! The road now entirely changed, and I got my first experience of old Norwegian roads. They are certainly not to be recommended, being abnormally

rough and not the slightest attempt at levelling. One might easily imagine it to be a choice specimen of the Yorkshire Fell breed. To ride the machine for more than 100 yards at a stretch was almost an impossibility, the undulations being so very sharp. Skirting the Grungedals vand for about eight miles I arrived in the early evening at Neylands saeter. Except in the large towns the houses are all built of wood. A foundation of rough stone is first erected to a few feet above the ground. This not only gives a level surface to the superstructure but protects the wood from damp, besides forming a convenient chamber for carts and lumber. A strong wood frame is then erected, which is covered with planks, the joints being caulked with moss. The roof is generally covered with bark and sodded all over. In the autumn there is a crop of grass which is duly cut down to increase the limited stock of hay. The woodwork is either painted white or simply varnished both inside and out. Some of the old houses and stores are ornamented with quaint carving, an art in which the natives excel, while many of the modern houses boast of considerable architectural merit. A pleasing feature are the balconies which open out from every floor. Large iron stoves are in every room.

From Neylands the bad road continued for seven miles to a junction where a new road opened this year leads direct to Dalen, on the Bandaksvand. This eighteen miles of old road is going to be re-made, and then there will be an excellent route all the way from the east coast to the west, through the Telemarken district. From the junction the road rises steadily for about a mile, then downhill and level all the way to Dalen, nearly seventeen miles. Those tourists who keep only along the west coast see only half the beauty of the country. The inland scenery is quite different from that of the coast, being much softer in character, and the vegetation more profuse. The mountains are covered with pine forests, while the valleys at the lower elevations are well cultivated. As I was riding along the Bortevand a magnificent ravine was reached at the junction of two rivers. This is one of the finest sights I saw. The rivers rush in roaring torrents down precipitous ravines, the sides of which, to the mountain tops, are covered with fir trees. Several hundred feet below the road can be seen as it winds its way down the valley beyond, but how to get there is a mystery until a sharp turn of the road reveals a long series of zigzags winding their tortuous course down the mountain side. It was indeed a magnificent sight, and all the more enjoyable from the suddenness with which it was approached. Dalen was reached about five o'clock. Supper not being served until late in the evening, I filled up the time by ascending the mountain up a good road to about 2,000 feet, and bagged a specimen of stone which is quarried here and used for sharpening

purposes, being split into long square strips. For the sake of variety I left the road and descended the mountain through the wood and down the cliffs, a proceeding which was soon found to be anything but easy; however, the bottom was reached without mishap, beyond a few scratches.

The following day was spent in a lazy fashion. The indifferent weather had been left behind, and it was again beautifully fine. Leaving Dalen at six a.m. by the lake steamer we passed down the Bandaksvand. In the hills on the south side are some extensive copper mines, which were pointed out as we passed along. On reaching the end of the lake there appeared to be no way out, but the steamer threaded its way through a tortuous passage which had been deepened by dredging, crossed another lake, then through another passage connecting it with the Flaavand, and finally into the new canal which has only been opened this year. The canal is a fine piece of engineering work, and has fourteen locks before it terminates at Ulefos, on the Nordsjo. By means of another canal at the south end of this lake, Dalen is brought into direct communication with the sea.

Another boat was taken at five o'clock, and we then steamed up the lake and to Notodden at the head of the Hitterdalsvand, arriving at eight o'clock, distance from Dalen about 75 miles. From here my original intention was to take the direct route to Kongsberg, but finding there was time to spare I cast in my lot with a party who proposed to make a detour by way of Hitterdal and Bolkesjo. The road was fairly good until Hitterdals Kirk was reached about four miles from Notodden. The rocks at the side of the road were splendidly glaciated, and another specimen was chipped off. The church is a very unique structure, entirely of wood, and one of the architectural curiosities of Norway. It is supposed to have been originally built in the 12th century, but has suffered greatly from an unskilful restoration in 1850. The windows are an innovation, the original design having only small air holes in their place. The doors and door frames and other portions of the structure are embellished with elaborate and fantastic carvings. I noticed the bible in use was dated 1633. Altogether it is a very interesting old building and well worthy a visit. Soon after leaving the church the road rapidly deteriorates, and the others having two ponies at their service soon got out of sight. After about six miles of undulating but almost unridable road, the route turns up a valley to the right through a pine forest, and hard walking became the order of the day. Evidently there had been no rain in this district for some time, as the river bed was as dry as a bone. Another six miles of laborious work and I overtook the others, who had halted at the first house for the last eight miles. We improved the opportunity by getting a little

refreshment while the ponies were resting. The driver appeared to think I had got my work set, and offered to wager he would arrive at Bolkesjo first; he evidently knew what was in store. The road now rapidly went from bad to worse, through endless pine forest. Before reaching our destination the driver offered to put the bicycle on the cart, the others having to tramp as well, but I was determined to go through with it, and ultimately had the satisfaction of arriving at the hotel first, eleven miles from the halting place for dinner. The hotel at Bolkesjo, is a new structure and the finest I saw in the country. The windows in the dining hall are single large sheets of plate glass, and the hotel being at a high elevation the view from them over the mountains to the west is exceedingly fine. A magnificent sunset was a pleasant finish to the hard day's work, and the memory of that evening will long remain as one of the greatest pleasures of the journey. Deep in the solitude of the wood lay the Bolkesjo while 300 feet below it was the Folsjo. Beyond were endless pine forests backed by the towering Telemarken mountains, with the giant Gausta, 6,180 feet, sharply outlined against a sea of gold. Not content, I climbed still higher up the mountain alone, the better to drink in the beauty of the scene. Yet not alone, for was I not communing with Nature, and when does she disappoint any who seek to woo her?

From Bolkesjo the road was still very heavy, and a stiff rise for two miles, but after the previous day's experience I was prepared for it. The route continued through pine forest for about five miles from Bolkesjo, making nearly 25 miles of almost continuous pine wood. Another 15 miles of indifferent but falling road and Kongsberg was reached at one o'clock. This is an uninteresting town of about 4,500 inhabitants, situated on the Laargen elv in the south part of the Numedal. The town owes its origin to the silver mines in the vicinity, and in more prosperous times had nearly twice as many inhabitants as at present. The mines, which are the property of the government, were discovered early in the 17th century, and although not nearly so profitable as formerly, they still yield an annual profit of over £12,000.

My fellow travellers continued their journey by rail from here, so after a parting "farvel" at the station, with many good wishes for a pleasant journey, I once again set off alone. The surface being very loose only slow progress was made, and the railway station at Hougsund, which I afterwards found was some distance from the village, was not reached until after seven o'clock. Failing to see any hotel or place to stop at for the night, I went to the station and attempted to make my wants known, but not a soul understood a word of English. Eventually two

girls managed to interpret my signs and accompanied me to the skyds-station in the village. Although this was only a poor station, everything was very clean, and the people did all they could to make me comfortable. A little rain fell in the night and the morning looked threatening, but I preferred to finish by road instead of taking the train, and had a good run to Drammen, 12 miles. On the way some very fine glaciated granite rocks were passed. Drammen is situated at the head of the Drammens fjord, and is one of the principal manufacturing towns in Norway. The trade, which chiefly consists of exporting timber, is very considerable, and vessels of large tonnage can load at the quays.

Being the first time I had reached sea level since leaving Odde, I took the opportunity to reset the aneroid, and was agreeably surprised to find that after seven days, during which the atmospheric pressure at sea level had been unsteady, the instrument only showed an error of about 100 feet.

Twenty-seven miles from Drammen the journey was completed, and I arrived at Christiana without mishap, after one of the most enjoyable tours ever made.

GEOLOGY & CLIMATE (Baedeker).

The peninsula contains no distinct mountain ranges like those occurring in most other countries, but mainly consists in its West part of a vast elevated plateau, descending abruptly to the western fjords and sloping gradually down to the plains of Sweden on the East side. The mountains are composed almost entirely of primary rocks, presenting nearly the same form as when originally solidified, and rarely overlaid with more recent formations, so that for the geologist they possess the charm of the most hoar antiquity. These rocks consist of granite, gneiss, mica, horneblende slate, quartzite, clay slate, limestone and dolomite, disposed in the form of strata, corresponding with which are occasional well-defined layers of more recent slate formations, and particularly of limestone. At places, notably in the Romsdal, the gneiss towers in most imposing pinnacles, 5,000 to 6,000 feet in height, unencumbered by any later formations.

About the year 1840 rocks of the Silurian formation were discovered in the vicinity of Christiana Fjord, and since that date other deposits of that period have been found, but nowhere of great extent. The largest Silurian basin is that of the Storsjo, in Jemteland. Coal occurs here and there in the peninsula. The coal measures of Helsingborg at the south extremity of the peninsula are of considerable value and extent.

The configuration of the mainland must at one time have differed greatly from its present form. That it was once higher

above the sea than now is assumed by the formation of the coast with its water and ice-worn fjords, straits, and isthmuses. On the other hand the sea appears within recent centuries to have receded at places. According to the most eminent of the Norwegian geologists, the elevation of the coast has taken place fitfully. Thus it will generally be observed that in all the Norwegian valleys and fjords there are several distinct terraces, between which there is a sudden and well-defined dip, and that the old coast lines, with their heaps of debris, descend abruptly at their lower ends at an angle of 25 to 30 deg.

All the most important glaciers and snowfields are situated to the south of latitude 67. The most extensive is the Jostedalsbrae, 515 sq. miles in area, and the largest in Europe. It descends to within 200 feet of the sea level. A similar ice mantle is the Folgefond, already referred to, and another of vast extent is that of Svartisen, within the Arctic Circle. The upper parts of these snow fields form immense and comparativly level expanses of snow and ice, uninterrupted by moraines or crevasses, except where they descend into the valleys, and rarely broken by peaks rising above them, Striated rocks are everywhere observable, from the coast line upwards, and the debris of moraines is distributed over every part of the country.

The coast is indented with numerous fjords, almost all of which have several minor ramifications. The east coast of Scandinavia was probably also at one time indented with fjords, to which the numerous inland lakes once belonged, but which have gradually been filled up by the alluvial deposits of the rivers. That the fjords have been formed, as might be supposed, by the erosive action of ice and water, seems to be disproved by the fact that they are often much deeper than the sea beyond their mouths. The Sogne Fjord, for example, is no less than 4,100 feet deep at places. The fact appears rather to be that these basins existed before the glacial period.

Temperature. The climate of the west coast is usually mild, being influenced by the Atlantic and the Gulf Stream which infringes upon it. In the same latitude in which Franklin perished, and in which lies the almost uninhabitable region of east Siberia, the water of these western fjords never freezes except in their upper extremities. As we proceed from west to east the temperate character of the climate changes, and the winters become more severe. The climate is most equable near Stavanger, where the mean temperature of January is 34·7 F., and that of July 55·5 F., difference 20·7 F. At Stockholm, on the other hand, the mean temperatures respectively are 24·8 and 63·5, difference 38·7 F. In the depth of winter the Loffoden Islands are not colder than Copenhagen, nor Hammerfest than Christiana.

Rainfall. In the interior of Norway less rain falls than on the coast. The maximum fall is at Flor where it sometimes reaches 90-91 inches per annum. August and September are the rainiest months in the east districts of Norway, but on the west coast the rainy season is sometimes later. In the neighbourhood of the Romdal the rainy season does not usually set in before December. Hail and thunderstorms are rare in Norway; the latter, however, are sometimes very violent on the west coast. August is the rainiest month in Sweden, especially in the north provinces, the mean rainfall being 20-18 inches.

The papers were illustrated by an excellent series of lantern slides of Norwegian scenery.

An interesting discussion on "Glacial Phenomena," suggested by the papers and lantern views, followed, in which Messrs. Carter, Kendall, and Howarth, took part.

The proceedings concluded with hearty votes of thanks to Messrs. Forsyth, Cuttriss, and Hardcastle.

JUNE 21st, 1894.

ANNUAL MEETING.

Mr. JOHN INGLEBY, President, in the Chair.

The Minutes of the previous meeting were read and confirmed.

The Rev. W. Lower Carter, M.A., F.G.S., exhibited a capital series of Tertiary fossils from the Isle of Wight.

The Report of the Council for the year 1893-94 was read by Mr. J. H. Howarth, F.G.S., and adopted.

A Financial Statement was made by the Rev. W. L. Carter, and adopted.

The Election of Officers for the ensuing year was then proceeded with, and resulted as follows:—

President: Rev. W. LOWER CARTER, M.A., F.G.S.
Vice-President: Mr. JOHN INGLEBY.
Treasurer: Mr. JAMES GURNELL.
Hon. Secretary: Mr. J. H. HOWARTH, F.G.S.
Hon. Assistant Secretary: Mr. SAMUEL W. CUTTRISS.
Hon. Librarian: Mr. SAMUEL W. CUTTRISS.

Members of the Council :

Mr. JAMES E. BEDFORD, F.G.S.,
Mr. GODFREY BINGLEY,
Mr. DAVID FORSYTH, M.A., D.Sc.,
Mr. THEO. T. GROOM, B.A., B.Sc., F.G.S.,
Mr. C. D. HARDCASTLE,
Mr. EDWIN HAWKESWORTH,
Mr. BENJAMIN HOLGATE, F.G.S.,
Mr. PERCY F. KENDALL, F.G.S.,
Mr. REUBEN NUNNS,
Mr. G. D. PATTERSON,
Mr. J. J. WILKINSON.

On the motion of Mr. J. J. Wilkinson, seconded by Mr. John Redmayne, a hearty vote of thanks was accorded to Mr. John Ingleby for his valuable services as President for the last two years, and to the other Officers of the Association for their careful conduct of the Society's affairs during the year.

"THE PERMANENCE OF CONTINENTS AND OCEANIC BASINS,"

By Mr. JAMES H. HOWARTH, F.G.S.

(*Abstract*).

The presence of sedimentary rocks over considerable portions of the land areas of the globe suggested to earlier geologists that sea and land must have changed places many times. As successive geological formations were found to be represented over large and widely separated areas, and were readily recognisable, not only by their fossil contents, but by their general appearance and lithological character, it was evident that each must have been laid down under similar conditions, and geologically speaking at the same time. It followed, therefore, that large portions of what is now dry land must have been below sea level during the same period, and so there grew from these facts a general assumption that continents and oceans must have swung to and fro like a see-saw; and as every part of the dry land had probably at some time or other been under water, so every part, or the greater part, of the sea bed might at sometime or other have been dry land.

It was only when Professor Dana suggested, from a study of the development of the North American Continent, that land areas have persisted throughout the greater part of known geological time, that attention was directed to the permanence

side of the question, and since then both points of view have received strong support.

Before proceeding to see what the opposing arguments are, and what is the present position of the controversy, it may be well to run over the broader physical facts and estimates which, in a greater or less degree, lead up to and illustrate the subject.

The total area of the globe is estimated by Mr. John Murray[1] at 196 million square miles. Of this 55 million square miles, or say 28 per cent., is land; and 141 million square miles, or 72 per cent., is water. The greatest height of the land is 29,002 feet, the greatest depth of sea yet sounded is 28,200 feet. The maximum vertical range is therefore, roughly speaking, 60 thousand feet, or $\frac{1}{700}$th of the earth's diameter, and in considering questions of upheaval, which we are accustomed to regard as being on an enormous scale, it is well to bear in mind that Mount Everest, the highest point of land, is only $\frac{1}{1400}$th of the earth's diameter, and that mountain ranges, relatively speaking, are little more than dust grains on the surface of an orange.

The mean height of the land is 2,200 feet; the mean depth of the sea is 12,600 feet. It is obvious, therefore, that if the globe were reduced to one common level, it would be covered with water 10,000 feet deep. Mean sphere level is therefore 10,000 feet below sea level, and it has been pointed out as a remarkable coincidence that exactly one half of the globe is above mean sphere level, and one half below it.[2]

A glance at a map of the world, say on the plane of the Equator, at once discloses that sea and land are very unequally divided, and that the greater part of the land area lies in a rough circle round the North Pole, occupying 42 per cent. of the whole surface in the Northern Hemisphere, and only 17 per cent. in the Southern. Another interesting feature is the rough parallelism between the coast lines, so that if the great land masses of the globe were movable they might be packed in together like a child's picture puzzle, the lands of the Western Hemisphere being pushed up to those of the Eastern, and, roughly speaking, fitting in.

The vast extent of the Pacific Ocean occupying more than one fourth of the surface of the globe is another striking feature, and in this connection may be mentioned Prof. G. H. Darwin's suggestion as to the genesis of the moon, viz: that the moon was thrown off from the earth's mass, and that the Pacific Ocean represents the scar. The Rev. Osmond Fisher[3] commenting on Prof. Darwin's theory further suggests that if this were so, the

1.—J. MURRAY. On the height of the Land and the Depth of the Sea. Scot. Geog. Mag., IV., 1. (1888).
2.—H. R. MILL. The Realm of Nature, p. 191. (1892).
3.—Physics of the Earth's Crust.

continental areas of the Western Hemisphere might have been broken off from the main land mass, and the Atlantic Ocean formed between, which would account for the parellelism between the coast lines, and support the theory of Continental Permanence.

Referring to the boundaries of existing land areas, littoral deposits between high and low water mark are estimated to cover 62,500 square miles, along coast lines of 125,000 miles, averaging half-a-mile in width.[1] Beyond low water mark the sea bed gradually slopes down to the 100 fathom line, which bounds an area of 10 million square miles. The 100 fathom line is important as marking, generally speaking, the limit of land derived deposits, and also the outer limit of continental masses. The area enclosed in it is therefore called the "Continental Shelf." Beyond the 100 fathom line the sea floor slopes comparatively rapidly to great depths, since while the 100 fathoms line bounds an area of 10 million square miles, the next 400 fathoms only bound an area of 7 million square miles. This area is called the "Continental Slope." Beyond the "Continental Slope" the sea floor drops rapidly to depths of 1,000, 2,000, 3,000, and 4,000 fathoms, and upwards. Land derived deposits are now left behind, and the sea floor is covered by a series of organic oozes and a red clay, occupying 114,590,000 square miles, or considerably more than half the surface of the globe.

The distribution of the deep sea deposits as disclosed by the researches of the Challenger Expedition throws light in some degree upon the question of permanence. The presence of a very small per centage of carbonate of lime appears to be synonymous with great depth. At depths averaging 1,996 fathoms, globigerina ooze covers an area of 49,520,000 square miles. At 2,500 fathoms it is rarely found, the proportion of $CaCo_3$ gradually decreasing towards abysmal depths to almost vanishing point. It thus appears clear that the shells of lime-secreting organisms are dissolved on reaching a certain depth, for below that depth and averaging 2,730 fathoms, the sea floor is covered by a red clay. This occupies 4,900,000 square miles in the Indian Ocean, 5,800,000 in the Atlantic, and in the Pacific 40,800,000 square miles, or by far the greater portion of the ocean floor. These deep sea deposits show no traces of mechanical action, or of any materials from the marine stratified rocks of continental areas, and the investigators concluded from the teeth of extinct sharks and other evidence, that "the accumulation in some red clay areas has been so slow as to form only a few inches since the Tertiary period." It is important to note that volcanic products are present nearly everywhere. Pumice and volcanic glass are widely

1.—Report on Deep Sea Deposits; Challenger Expedition.

distributed. The former can carry for great distances in the air or currents, but the latter presumably lies not far from its source.

So far as the Challenger soundings have disclosed, the ocean floors, and especially as regards the Pacific, are vast undulating plains, the slopes rarely exceeding 100 feet in a mile, except where the floor is abruptly thrown up for an island, or near the margins of great continents. For hundreds of miles the slope is hardly noticeable, and there is no sign of surface irregularities, such as mark land areas.

A series of sections across the great oceans and continents suggest that the earth's crust is thrown into great undulating folds, more abruptly marked on the land areas, and less so in the Pacific Ocean bed, but still a series of folds, the ridges of which represent our mountain ranges, islands, and archipelagos; the depressions our land plateaus and valleys and our deep sea areas. If the outer crust could be peeled off and turned upside down, the great mountain ranges might be our deep seas, and our present abysmal areas, mountain ranges, and plateaus.

If the water supply outside the earth's crust has been constant since its formation, and the globe has condensed and consolidated from a liquid or viscous mass, there would be a time when the crust was at one level, and entirely water covered. Subsequent contraction would sag down portions of the crust and upheave others. The water would retire into the down-sagged regions, and so the upheaved portions, formed along certain lines of weakness, however caused, would become dry land. Lines of weakness once formed and pushed up above sea level would ever remain lines of weakness, and more readily respond to subsequent pressure, lateral or vertical, set up by further contraction, or volcanic action, and from decreased pressure and less density, would be more likely to become the areas of future oscillation and fracture, than the regions covered by deep water. If these considerations are well founded the frequent oscillation of land areas, as compared with sea, and especially deep sea, areas, is what we should expect, and is what has apparently occurred.

Having reviewed the physical facts and estimates which bear upon the subject, let us now see what are the arguments for permanence. These are, perhaps, most clearly and forcibly stated by Dr. A. R. Wallace.[1] They may be briefly summarised thus:—That the character and composition of sedimentary rocks, their narrow bands rarely more than 150 to 200 miles wide, the presence on all well-examined continents of plants, or land animals, or both, in almost every geological period, prove them to be lacustrine, estuarine, or shore deposits, necessitating the proximity of

1.—Darwinism.
Island Life.
Permanence of Continents and Oceanic Basins; Natural Science, Vol. I., No. 6, 1892.

denuding land areas. That the Chalk is a shallow water deposit, *i.e.*, formed at a depth measured by hundreds and not thousands of fathoms. That as upheaval and depression on any large scale would nearly balance each other, the fact that mean sphere level is, as we have seen, 10,000 feet below sea level, whole continents would disappear before any corresponding portion of the ocean floor anywhere approached the surface. That on all the present continents geologically explored we find a tolerably complete series of the chief formations. He quotes Mr. Darwin's argument, in his "Origin of Species," that the absence of Palæozoic or Mesozoic rocks in most of the islands with which our great oceans are studded, suggests that neither continents nor continental islands existed where our oceans now do, or we should have had some of the denuded materials upheaved. New Zealand and the Seychelles are admitted exceptions. (To these must be added Spitzbergen, the Phillippine Islands, New Caledonia).[1]

Dr. Wallace argues for the permanence of ocean basins from the contour of the ocean floor as we have seen previously, and generally draws the same conclusion from the distribution of the fauna and flora of the globe.[2] As late as August, 1892, Dr. Wallace writes[3]:—"All that is necessary to maintain, therefore, "is that existing continents with their included seas, and their "surrounding oceanic waters as far as the 1,500 fathom, or in "some extreme cases the 2,000 fathom line, mark out the areas "within which the continental lands of the globe have been built "up; while the oceanic areas beyond the 2,000 fathom line, "constituting according to Mr. Murray's data 71 per cent. of the "whole ocean, have almost certainly been ocean throughout all "known geological time." Similar views based on similar grounds have been held by Professor Dana, Sir A. Geikie, Mr. Darwin, and Dr. John Murray, and by the Rev. O. Fisher, on purely physical grounds.

The case against permanence is very clearly stated by Mr. A. J. Jukes-Browne.[4] He instances the Chalk as refuting Dr. Wallace's statement that deposits uniform in character and more than 150 or 200 miles wide were rarely, if ever, formed at the same time, and argues that the Chalk was formed under similar conditions to modern oceanic ooze, and is of similar though not identical composition.

In reply to Dr. Wallace's argument that no modern oceanic islands, except New Zealand and the Seychelles, contain any Palæozoic or Mesozoic rocks, as might be expected to occur in

1.—W. O. Crosby. Geol. Mag., Vol. X., p. 251.
2.—Island Life.
3.—Natural Science (Op. Cit.)
4.—Building of the British Isles, Chap. XV.
Natural Science, Evolution of Oceans and Continents, Vol. I., Sep. 1892.

old continental lands, Mr. Jukes-Browne quotes Mr. Crosby[1] as showing other exceptions, such as Spitzbergen, 400 miles from the nearest part of Europe, consisting largely of Palæozoic and Mesozoic rocks, the Phillippine Islands (Mesozoic), and New Caledonia separated by 700 miles of deep water from Australia, and where stratified rocks both of primary and secondary age occur. He further quotes Mr. Crosby that "Oceanic islands are, "of course, merely the tops of submerged mountains, and it is "only with the highest points of continents that they can be properly compared." Mr. Jukes Browne proceeds to say that "The present continents are the outcome of a long series of "geological mutations, and that each phase was an episode in a "long process of geological evolution," and that in Pliocene time the outlines of continents were very different from the present, and that Miocene geography differed still more. As to the argument derived from the contour of the ocean floor he says, "That it applies most completely to the deeper and consequently "to the old portions, that our knowledge of sub-oceanic contours "is very limited, and that long-continued deposition and out-"pourings of lava would tend to obliterate any pre-existing "irregularities."

Mr. Jukes-Browne refers to an important suggestion by the Rev. O. Fisher[2] that the volume of ocean water has not always been the same, and that consequently the relative proportions of sea and land were at one time very different, and oceans have been gradually increasing in depth and extent. He readily admits that the deeper parts of existing oceans are of great antiquity, and that modern oceans and continents are of very ancient date. Similar views based on similar grounds, or some of them, have been held by Sir Charles Lyell, W. O. Crosby, G. S. Gardner, Prof. Hull, Prof. Prestwich, Prof. J. Le Conte, Dr. W. T. Blandford, Prof. Bonney, and Prof. Edward Suess.

An important exception to some of the arguments for permanence is found in the Island of Barbados, and fully described in two valuable papers read before the Geological Society in February 1891, and January 1892, by Mr. A. J. Jukes-Browne and Prof. J. B. Harrison, who have carefully surveyed the island.

After describing the physical structure of the island, and the succession of beds which include organic oozes of deep water origin, Mr. Howarth said these beds tell a singular and interesting story. The foundation beds of the Island were formed in shallow water. Then the island sank while a calcareous ooze was formed requiring a depth of from 500 to 1,000 fathoms. Subsidence went on, and a radiolarian ooze was deposited, comparable to the

1.—Geol. Mag. (ante cit.)
2.—Physics of the Earth's Crust.

deepest parts of modern oceans, and indicating a depth of at least two to three thousand fathoms, and possibly more. Then the movement was reversed, and the area rose to say within 1,000 fathoms of the surface, and a second calcareous ooze was laid down, in open ocean far away from land. An overlying red clay suggests a second subsidence, since the investigators concluded it could hardly have been laid down in less than 2,000 fathoms, after which elevation must have gone slowly on until the depth became suitable for coral growth, which steadily proceeded until the island emerged from the ocean, and is now going on round its shores. This forms a striking example of oscillating earth movements far from present land, and furnishes an instance of true deep sea deposits in a land area, the absence of which had long formed an argument to support the permanence theory.

Since Messrs. Jukes-Browne and Harrison published these papers, a pteropod marl, indicating fairly deep water conditions, has been found in Jamaica, and other radiolarian beds, such as those of Barbados, in the heart of the West Indian area. Mr. R. J. L. Guppy has described a similar set of beds in Trinidad, and Dr. G. J. Hinde and Mr. W. M. Holmes the Oamaru deposits in New Zealand, which they regard as comparable to the diatom ooze fringing the south polar regions, and indicating a depth of 2,400 to 3,000 fathoms.

These instances furnish evidence inconsistent with the permanence theory as a whole, and dispose of the argument that no beds corresponding to deep sea deposits appear in land areas. Although it may be said that the West Indian region lies near the border of a large continent, and may have shared in the oscillations which have marked land areas, the same can hardly be said of New Zealand and the Oamaru deposits. The deep ocean floors far from land may have been "permanent through all geological time," but it is possible that even there land derived materials may have been covered beyond the reach of the dredge. While the balance of evidence, established and circumstantial, is on the whole in favour of the permanence of continents and oceanic basins, it must be remembered that the most recent refuting evidence has been the most damaging, and the cautious student will do well to hesitate before expressing too confident an opinion.

Mr. Howarth's paper was illustrated by a series of lantern slides.

A discussion followed in which Messrs. Wilkinson, Carter, Redmayne, Patterson, Gurnell, and Nunns took part, and the proceedings closed with a vote of thanks to Mr. Howarth.

REPORTS OF
FIELD EXCURSIONS.

JULY 1st, 1893.

EXCURSION TO RIPON.

Leader, Mr. P. F. KENDALL, F.G.S.

Never, perhaps, has the Valley of the Ure looked lovelier than was the case under the brilliant sunshine of this Saturday afternoon, and the members of the Leeds Geological Association, who journeyed under the guidance of Mr. P. F. Kendall, F.G.S., to explore the rocks of Ripon, had a rare opportunity of studying the scenery as well as the strata of this noted district. Once through the smoky darkness of Bramhope tunnel, we felt a joyous relief from the closeness of the city and the nastiness of the Aire, and were ready to admire Nature and her works. On crossing the Wharfe an excellent view of the old river terrace was obtained, standing up like a rampart on each side of the stream, and some distance away from its present channel. The fine crags of Almescliff were soon passed to the left, and crossing the viaduct Harrogate was reached.

One often hears of the advantages of a well-warmed carriage, but a crowded compartment on a roasting July day is somewhat overpowering. The usual course, one would think, when the day is hot and the train crammed, would be to put on an extra carriage or two: but, strange to say, the process was reversed at Harrogate, where we were turned out of our seats that the carriage might be taken off, and bid to cram ourselves in the already full compartments, or pace the platform till the next train arrived. By a few manœuvres we managed to get on our way without more than the usual delay, and at Nidd Bridge, leaving behind the level country, entered a stretch of low, undulating mounds, with curious, flattened hollows which have no drainage outlet, and whose structure, therefore, cannot be explained by water erosion. This area, our leader explained, was occupied by the terminal moraine of the glacier which, descending the valley of the Ure, had deposited its burden of debris between Ripon and Nidd Bridge. At Ripon the Ure runs southwards in a wide gorge between the Magnesian Limestone on the west, and the New Red Sandstone beds on the east, forming roughly at this point the dividing line between the two formations. On the hill-side to the north of Ripon Station are a number of swallow-holes, towards which our party first directed their steps. These swallow-holes are large funnel-shaped depressions on the gently sloping hill-side, in the red Keuper sandstone. The line along which these depressions exist is very near the junction

with the Permian Beds, and to explain them it is suggested that the underlying limestone has been dissolved away, undermining the sandstone beds, which have gradually collapsed. Our leader explained that these swallow-holes resembled features that were common in the Chalk of the South of England. The Mountain Limestone is exceedingly compact. Water attacks it on the outside, forming those curiously contorted stones found on most of the Carboniferous Limestone plateaux, and widens the joints, producing swallow-holes and caverns, as at Ingleborough. But in the Chalk there are no caverns and no underground rivers. The Chalk being very porous, water saturated with carbonic acid sinks into the mass of the rock, and bodily dissolves it away, leaving on the top of the Chalk, outside the areas of glaciation, where it has been removed, clay full of flints, the insoluble residue left after the removal of the Chalk by the carbonated water. In the Chalk pits of the south, great hollows, or pipes, are found full of gravels and sands, which are arranged usually in layers bending round parallel to the sides of the pipe. These gravels are often Pliocene beds, remnants of a series which once extended far and wide over the surface. The greater part of these beds has since been removed by denudation, but where the Chalk was dissolved the overlying beds were gradually let down into the hollows, and so preserved. This kind of action Mr. Kendall conceived to be the explanation of the Ripon swallow-holes. The Magnesian Limestone is much more porous than the Carboniferous Limestone, and hence much more nearly resembles Chalk in its behaviour under the action of carbonated water. The limestone would appear to have been gradually removed, and the undermined Keuper sandstones subsequently collapsed. The New Red beds are only partially represented in this area. The Bunter series is not seen at all, though 2,000 feet thick in Lancashire. The Keuper series, though about 5,000 feet thick in Lancashire, here only attains to a thickness of 500 feet. The surface is largely covered with drift, brought down by the Ure glacier, which contains boulders of Mountain Limestone, Carboniferous sandstone, Magnesian Limestone, and other local rocks. In an adjoining field, surrounded by trees, two very interesting swallow-holes were found. The lower one was a pit about 25 feet in diameter, with steep sides 30 feet in depth, showing a good section of the bright-red Keuper sandstones. This pit, which was dry, occupied the centre of a large funnel-shaped depression, such as we had seen before, and was evidently a further stage in the evolution of the swallow-hole. In an adjoining plantation was a deeper pit, about 30 feet in diameter, and 60 feet to the surface of the water, which looked dark and gruesome below. A start was then made for the drift-covered Permian beds, over the fine stone bridge which spans the Ure, and a glance into the clear stream running below made the memory of the black, unsavory waters at Leeds Bridge only darker by the contrast. Skirting the town, the stone heaps left by the widening of the Cemetery Road received careful attention, revealing many ice-scratched boulders of Mountain Limestone, as well as Carboniferous grits, Magnesian Limestone and breccia, chert, and a block suspected to be Silurian. Further on we visited a pit at the

edge of the wood behind the Episcopal Palace, which showed a fine section of drift beds. Under a thin deposit of boulder clay, with angular blocks, came 6 feet or 8 feet of compact sand, in which lumps of boulder clay had been caught up. Underlying these sands were 10 feet of pebble beds, whilst a line across the centre of the section appeared to be an indication of horizontal rock movement. In this quarry the party were photographed by Mr. Washington Teasdale, F.R.M.S., after which, passing the fine Tudor palace of the Bishop, we made for Ripon and refreshment. A short stroll by the Cathedral of St. Wilfred brought us to the station, and to the conclusion of our pleasant afternoon's ramble amongst the rocks.

JULY 8TH, 1893.

EXCURSION TO MARSH LANE CUTTING, LEEDS.

Leader, Mr. B. HOLGATE, F.G.S.

Whilst Harrogate was suffering bombardment by hailstones, the Leeds geologists, led by Mr. B. Holgate, F.G.S, were essaying the examination of the new railway cutting near Marsh Lane Station, and managed, between the thunderstorms, to obtain a good look at the interesting sections displayed therein. A heavy rainfall about the time of meeting gave us an opportunity of quietly contemplating the beauties of Marsh Lane for twenty minutes before a start could be made. Our leader then took us into the old brick pit, behind the station, where he rapidly explained the work to be done. Then, entering the new cutting, we were soon eagerly examining the deep excavations made preparatory to the removal of the tunnel. The beds exposed there belonged to the Lower Coal Measures. Above the west end of the tunnel a fine section of the Beeston Better Bed was found about 12 feet below the surface, and exposing 8 feet of good coal, separated into several seams by thin impure partings. After crossing a small fault, the party had an opportunity of viewing and admiring the power of one of the steam excavators at work, but soon pressing forward to treasures geological, a band of blue-bind was assaulted, under our leader's direction, and from it were wrested abundant fine specimens of fern and other vegetable remains, in excellent condition. Some excellent calamite stems, standing as they grew, were also examined, one especially showing roots branching in a most unusual way for that kind of plant. When the bags had been filled to overflowing, a move was made for the east end of the tunnel, sections of several small faults being clearly seen in the cutting, which brought down a sand-rock deposit very much false-bedded and of considerable thickness, which, near the East End Park, was seen faulted against Middle Coal Measure shales, brought down by the great 35 yards fault. Before separating, a unanimous vote of thanks was accorded to Mr. Holgate, on the proposition of Mr. Carter, seconded by Mr. Gurnell, and supported by Mr. Swithenbank.

JULY 10TH, 1893.

EXCURSION TO KIRKBY MOORSIDE.

YORKSHIRE NATURALISTS' UNION.

Leaders, Mr. W. L. CARTER, M.A., F.G.S., and
and Mr. J. W. STATHER, F.G.S.

There was a fair muster of members at the 104th meeting of the Yorkshire Naturalists' Union, to explore the little known regions of Kirkby Moorside. With the exception of a severe thunderstorm that gave the early comers a wetting, the day was favourable, but a piece of bad railway arrangement left the Leeds section two hours to wait at York, and all for the sake of five minutes' stoppage of the local train. This seriously cramped the work of some of the geologists.

Kirkby Moorside lies on the northern edge of the great flattened hollow known as the Vale of Pickering. This roughly oval area is elongated in an east and west direction, and is bounded on the north, west, and south-west by Oolitic hills, and on the south-east by the Chalk Wolds. It is almost entirely covered by alluvial deposits and post-glacial sands and gravels.

The remarkable course of the Derwent—which, rising near the coast, flows westward instead of taking the valleys to the east—is a well-known instance of erratic river-flow, the original exit having been choked up by the glacial deposits, the remains of which are now so well seen near Filey. By this seaward barrier the drainage waters of the Vale of Pickering were dammed up, and a lake formed, which ultimately found an exit over the lowest part of the Oolite escarpment at Malton, and gradually the present gorge was excavated.

On either side of Kirkby Moorside a long sinuous valley runs northwards, cutting deep grooves into the table-like hills and exposing interesting sections of the Middle and Lower Oolitic beds, which dip gently to the south, and are exposed in order as we pass northwards. The Lower Oolites, which in this area consist of a great series of estuarine, marine, and freshwater beds, are divided into three series, "each of which is capped by a thin but well-marked band full of marine fossils" (Fox-Strangways), are exposed at the northern extremities of these valleys, but in their lower reaches the beds seen are confined to the Middle Oolites. It is to these that the attention of the Geological Section was principally directed. Immediately above the dark shales of the Cornbrash (the topmost bed of the Lower Oolites) comes the Kellaways rock, which in this area has a thickness of about 70 feet, and "is a tolerably massive sandstone which is ferruginous and fossiliferous in the upper part." Above this comes the Oxford Clay, which in this area is a grey, sandy shale, "lithologically very unlike its equivalent in the South of England." Its fossils are few in number and badly preserved.

The Lower Calcareous Grit, about 150 feet in thickness, in this area consists of a massive sandstone which passes gradually into the Oxford Clay beneath, and becomes "more calcareous in its upper part until it passes into the true limestone above." Above this come the

Passage Beds, which in this area lose much of the distinctness which characterises them more to the east, and are "less ferruginous and rather more massive in character." The capping rock of a great part of the tabular hill above Kirkby is the Coralline Oolite, a massive thick-bedded limestone "composed of minute oolitic grains with a great number of fossils." This limestone is divided into two principal beds, separated by a set of sandstones known as the Middle Calcareous Grit. Kirkby Moorside itself stands on the Upper Calcareous Grit, whilst the rising ground immediately above the town, to east, west, and south, is capped by blue Kimeridge Clay. This clay is supposed to underlie the greater part of the alluvial and lacustrine beds that cover the Vale of Pickering, but is only revealed in occasional isolated hills which rise above the general level of the plain.

The Boulder Clay in the neighbourhood of Kirkby is not more than a few feet thick. It is exposed in the railway cuttings, and consists of stiff clay with erratic boulders.

In the Coralline Oolite of this area there are many caves, one of which—the Cave of Kirkdale—is celebrated by the researches of Buckland. This cave, which is situated at the entrance to Kirkdale, contained an extensive accumulation of bony remains covered by a deposit of mud, the whole overlaid by stalagmite. "It is situated about half-way up the face of the quarry along an irregular line formed at the junction of the Chemnitzia limestones with the more earthy limestones above. . . . It is probable that at this horizon in the limestone are formed the numerous 'swallows' or underground channels, in which most of the streams in the neighbourhood lose a part or all of their water, and if the denudation of these valleys was carried 100 feet lower, it is probable that a fine series of caves would be exposed in this region" (Fox-Strangways). No human remains or traces of human workmanship have been found in this cave, nor is there evidence of more than one period of occupation by predacious beasts (Phillips). It would appear to have been a hyæna den, most of the bones being well gnawed, and the proportion of hyæna remains being exceptionally large. Twenty-seven species of mammalia and birds having been found in it."

The Geological Section left Kirkby Moorside by the Manor Vale, then crossed to Kirkdale by way of the Gillamoor Road and Hagg Farm, worked down Kirkdale from Hold Chaldron Mill to the Cave, and then back to Kirkby by the low road. The divisions of the Middle Oolite examined during the day were:—

1.—The Upper Calcareous Grit.
2.—The Upper Limestone.
3.—The Middle Calcareous Grit.
4.—The Lower Limestones.

1. The Upper Calcareous Grit was seen in Manor Vale, capping the cliff opposite the ruined castle.

A peculiar argillo-calcareous stone of very unequal development called locally "The Throstler," was also noted here, forming a narrow band between the Upper Calcareous Grit and the Upper Limestones. In a quarry near Hagg Farm this same rock was observed to be at least twelve feet thick.

2. The Upper Limestone was also best seen in Manor Vale, especially in the quarry at the north end of the valley. Here the weathered surfaces showed a mass of fossils, quite easy to determine, but, for the most part, defying extraction.

3. The Middle Calcareous Grit. This was observed in the dry bed of the Hodge Beck, in Kirkdale, opposite the church. No fossils seen.

4. The Lower Limestones. The best sections of this division were also seen in the Hodge Beck, between Hold Chaldron Mill and Kirkdale Church.

Many of the streams in this district flow underground for some distance, leaving their courses above-ground quite dry, excepting in wet seasons. This was observed to be the case with Hodge Beck, for, just below Hold Chaldron Mill, it disappears bodily into a swallow-hole.

Perhaps, in some respects, the most interesting item in the day's proceedings was the visit to the celebrated Kirkdale Cave. Since the time of Buckland about thirty feet of it have been quarried away, and it is now of little interest, excepting in its associations. However, several members of the section, armed with candles and braving all discomfort, entered, and managed to crawl and wriggle a distance of twenty or thirty yards.

The geologists were much indebted to their local guide, Mr. Bowes.

JULY 15TH, 1893.

EXCURSION TO BOLTON AND EASTBY.

Leader, Mr. R. H. TIDDEMAN, M.A., F.G.S.

A fine St. Swithin's Day tempted the Leeds geologists out to essay the exploration of a section from valley to moorland in the neighbourhood of Bolton Abbey Station. The leader was Mr. R. H. Tiddeman, M.A., F.G.S., of Her Majesty's Geological Survey, who pointed out some of the chief points to be noted in the compilation of a geological map of the district. Between the main Carboniferous Limestone and the Millstone Grit in this area come the Bolland shales corresponding to the Yoredale beds of the northern dales. In this shaly series there are two bands of limestone which receive their names from neighbouring villages. The lower of these, the Embsay Limestone, was found at the head of a gill, along the side of which the party struck northwards out of the Skipton Road. At the side of the path as we climbed the slope was seen the socket of one of the Bolton way-side crosses, cut out of a block of pebbly Millstone Grit. After examining two or three exposures of the Embsay Limestone the party moved upwards, and the main pipe of the Bradford waterworks supply being crossed, a straight cut was taken for the moorland ridge which encircles Barden Reservoir, from which to the left the fine cliff-like escarpments of Eastby and Embsay Crags stood out boldly. In the ascent to Halton Moor, a little plantation was passed in which the Eastby Limestone was found. This proved to be largely made up

of encrinite stems and other fossiliferous remains, with shaly partings and bands of chert. This limestone, though variable in thickness, is fairly persistent at the same horizon, which is about the same as that of the Hardraw Scar Limestone of the north. In some places it is almost a breccia, and near Cracoe it expands into the great reef-knolls, full of fossils, so well known to Craven geologists. The leader here took the opportunity to point out the steepness of the dip and the line of strike, which was roughly parallel to the moorland ridge above. In surveying, the geologist would follow the strike in the expectation of finding a continuance of the same bed. If the bed stopped short, a fault would be suspected, and confirmatory evidence sought. On the north side of the Craven faults all the limestones occur between the Eastby Limestone and the Millstone Grit. Still ascending, our way led over mounds of drift material, which formed a rounded ledge on the hill side covering the Bolland shales. This drift, Mr. Tiddeman explained, was probably not true boulder clay, but material washed from the hill sides by torrents, whilst the valley was choked with ice, being similar to the ridges found at considerable elevations in many Norwegian valleys. After crossing the rich pasture land of the limestone shale area, the contrast with the wild moorland vegetation so characteristic of the Millstone Grit was very striking. At Howgill Nook a halt was made whilst our leader explained that there were two principal grit beds forming the escarpment, each forming a distinct feature on the hill side. The upper bed was coarse and pebbly, whilst the lower, on which we stood, was finer grained and corresponded to the Pendle Grit, which was seen far away, o'er-topping many an intervening ridge, on the brow of Pendle's lofty hill. The party then walked along the outcrop of the Pendle Grit, and noted the effect of two small faults, which threw the upper grit down into a line with the lower, from which its prominent quartz pebbles plainly distinguished it, forming a series of parallel terraces down the hill slope. Reasons were also given for supposing that a strike fault here ran along the line of the Skipton and Barden Road, bringing down a portion of the upper grit, and leaving a bold escarpment behind, and throwing forward into prominence, further on, the fine crag which overlooks Eastby. A slight detour was made to a point from which the projecting rocks of the escarpment might be seen against the sky-line, when we were able to admire at our leisure a huge head, somewhat resembling a caricature of the late Mr. Bradlaugh, though, as some remarked, the contour of the stony portrait did scanty justice to the brain power of the well-known original. Here Mr. Tiddeman was obliged to leave us, but not before he had received a hearty vote of thanks for his able guidance. The party then tramped to the little village of Eastby, "far from the madding crowd," in the hope of refreshment, and were well entertained so far as could be expected, considering the unexpectedness of the descent "like a wolf on the fold." A flying visit was then paid, under Mr. Wilkinson's guidance, to the quarries of Skipton stone, near Embsay Station, the steep hill side being climbed for a near examination of the upturned edges of the limestone beds, which had been

bared for the purpose of quarrying. The effects of weathering along lines of unequal hardness were examined, and their resemblance in places to glacial groovings was noted. So far as the limited time permitted examination, these groovings appeared to be the product of subaërial weathering, as they were frequently traced round the corners into joint crevices, or were deeply marked in little hollows that ice would have smoothed down, but, when the surfaces were freshly exposed, our leader reported that ice-scratched surfaces were visible. A forced march then had to be made to the station, which brought our expedition to a "glowing" termination.

AUGUST 7TH, 1893.

EXCURSION TO GISBURN AND SAWLEY ABBEY.

YORKSHIRE NATURALISTS' UNION.

Leader, Mr. R. H. TIDDEMAN, M.A., F.G.S.

It was a happy idea on the part of those who arranged the Yorkshire Naturalists' Union excursions for the present year, to include that part of the valley of the Ribble which extends from Gisburn to Sawley Abbey. It is a remarkably picturesque stretch of river flowing through a narrow gorge, well-wooded on both banks, and is not known so well to Yorkshire men as it ought to be. Our Lancashire neighbours are by no means insensible to the attractions it offers, as may on any holiday be seen in the extraordinarily large number of crowded and well-appointed brakes which visit Gisburn and Sawley for a day's drive. Sawley Abbey is a once famous Cistercian monastery, founded in 1137 by William Baron Percy, but now a shapeless mass of ruins, situated close to the left bank of the Ribble, at a point where the gorge in which it flows broadens out into a level plain, and it is interesting as being an ancient example of jerry-building, soft shales having been used when there was a large supply of good building stone available in the neighbourhood. At Gisburn the chief object of interest is the park belonging to Lord Ribblesdale, in which, until the year 1859, when the last example was killed, existed the last herd of genuine wild cattle known to have been in Yorkshire. A good description of the breed is given in Whitaker's "History of Craven," with a couple of excellent illustrations, and a specimen is preserved in the Manchester Museum. These cattle differed from the Chillingham herd in being polled or hornless, and their ultimate extinction was the consequence of their having been bred in-and-in for many generations. At Bolton-by-Bowland the chief objects of interest were the grounds and conservatories, to which, by the kindness of Mr. C. B. E. Wright, the members had full access. The members began to assemble on the Saturday, several putting up at various inns at Gisburn and Sawley, and being thereby able to make many useful observations before the main body arrived on Monday. The weather, which was threatening, had doubtless kept many away, but, fortunately for those who attended, rain kept off.

The geologists assembled at Chatburn Station, at 11.35, under the leadership of Mr. R. H. Tiddeman, M.A., F.G.S., whose work on the Geological Survey had rendered him perfectly familiar with the district. The first place visited was the Bold Venture Quarry just outside of Chatburn Station, where the Carboniferous Limestone is extensively worked. The beds in this quarry are tilted up at a high angle, and as the boulder clay, which covers the eastern slope of the hill, is removed, the surface of the limestone is shown to be smoothed and scored by glacial action, the markings showing a movement of the glacier from the north-east. At the other end of the quarry a good example of slickenside was seen, due to the movement of the beds along a line of fracture. The party then walked along the road to Sawley Abbey, but were disappointed in not being able to see the upturned limestone strata to be seen in the river-bed when the water is low. A slight diversion was made for the examination of a limestone quarry on the hillside, which showed an interesting flexure of the limestone beds, relieved by an overthrust, forming a reversed fault.

The party next visited Sawley Abbey, which was pointed out by the leader as an ancient example of jerry-building, the walls being formed of calcareous shale, which has undergone rapid disintegration, instead of the solid limestone of the neighbourhood being used. The party then crossed the Ribble, and made their way over the alluvial flat to Bolton Park, where they were shown over the conservatories by the kind permission of Mr. C. B. E. Wright.

From Bolton Mr. Tiddeman struck back to the Ribble, and for some distance the party made their way along the high, wooded bank of the river gorge. When an opportunity was afforded them, a descent was made to the river-side, and a rough scramble along a very primitive and rocky path by the water's edge ensued. The Ribble between Gisburn and Sawley has excavated a gorge through the Carboniferous Limestone beds, which are the lowest beds seen in the district. As the river runs almost along the strike of the beds, very little variation in the geology was seen, and these lower beds did not yield any fossils on the present occasion. A return to the upper regions, and a rapid walk across country to Gisburn Station, completed the afternoon's ramble.

During the day Mr. Tiddeman explained the structure of the district, which was pleasantly undulating, with the huge hump of Pendle Hill rising high to the south-east. The strata of this district are thrown into a series of folds running from south-west to north-east, the central anticline (Clitheroe anticline) running past Skipton to Bolton Abbey. The Clitheroe Limestone beds of the Carboniferous Limestone series form the centre of this anticline. Above this more massive rock come shales with limestone bands, which often thin out in each direction, and are reef-like in character. Then comes a more massive bed, the Pendleside Limestone, above which, separated by shales, is the Pendleside Grit. Higher still is a series of thick shales, the Bowland Shales, which are the equivalents of the Yoredale beds of the northern Yorkshire dales. The steep western slope of Pendle Hill is due to the rapid disintegration of these comparatively soft be[illegible]

The summit of the hill is formed of the massive Pendle Grit, the basement bed of the Millstone Grit Series, to the eastward of which come the Kinder Grit, the Third Grits, and the Rough Rock, separated from each other by shales, and overlaid by the Coal Measures of the Burnley Coal Field.

AUGUST 12TH, 1893.

EXCURSION TO WETHERBY.

Leader, Mr. J. E. BEDFORD, F.G.S.

The report of considerable excavations being made in the gravelly deposits underlying Wetherby, in connection with the new drainage scheme, brought over from Leeds a party of members of the Leeds Geological Association, to examine and report on these beds. The party, under the leadership of Mr. J. E. Bedford, F.G.S., travelled from Leeds by the 1.45 train, and on arriving at Wetherby proceeded directly to examine the street sections, and the heaps of boulders excavated therefrom. The first section showed about two feet of made ground, underneath which came a gravelly deposit, which in some places gave way to a bed of coarse, dirty sand. Proceeding to the market-place, a more extensive exposure was examined, showing below the made road 22 feet of sands and gravels, the bottom of which was not then reached. The boulders varied much in size, the largest being as much as two feet in diameter.. The larger boulders were sub-angular, whilst many of the smaller ones, and especially the sandstones, were well rounded. Varieties were found of white crystalline limestone, resembling the Carboniferous Limestone of Upper Wharfedale; dark limestones, such as those of the Bolton district; Millstone Grit and finer sandstones, ganister, Magnesian Limestone, and pieces of black chert. Several of the boulders yielded Carboniferous fossils. The matrix was a dirty sand, and many of the blocks were encrusted with carbonate of lime. A cutting in Victoria Street showed that the majority of the stones were well rounded, and stood at all angles. The matrix was more clayey in this part, but did not resemble a boulder clay, and the cavernous nature of the deposit was another piece of evidence confirming this view. A careful examination of the stones was made, but no undoubted glacial scratchings could be found. At Mr. Bedford's invitation, Mr. P. F. Kendall, F.G.S., gave a short address on the origin of these beds. Whilst not dogmatising on the matter, he believed that there was here a deposit of glacial age, forming a high terrace. To the east the great York glacier had left enormous moraines; to the west the Wharfe glacier had left undoubted traces of its existence. The deposit here, however, did not seem to have the characteristics of a boulder clay. It appeared much more to resemble an accumulation of material brought down Wharfedale by great rushes of water caused by the rapid melting of the glacier front in springtime. Such spring floods would wash down great quantities of debris, which had accumulated at the front of the Wharfedale glacier, and thus this terrace had been probably produced.

The party then proceeded, under Mr. Bedford's guidance, to examine the exposure of the Lower Magnesian Limestone seen in the gorge under Crow Croft Bank. In Yorkshire there are two beds of Magnesian Limestone, separated by the Middle Marls and Sandstone. At the top of the series are the Upper Marls, and at the bottom the Quicksands and Lower Sandstone. To this series of beds, intermediate between the Carboniferous and Triassic formations, the name Permian was given by Sir Roderick Murchison from the province of Permia in Russia, where he found them well developed. They overlie the Carboniferous rocks unconformably, lying on Millstone Grit near Wetherby, on Lower Coal Measures near Barwick, and on Middle Coal Measures near Garforth. At Bardsey they are seen to rest on the upturned edges of the Third Grits of the Millstone Grit series, this section showing that the whole thickness of the Coal Measures and the Rough Rock had been deposited, upheaved, and denuded before the Permian beds were laid down. This would require a great interval of time between the deposition of the two series of beds which now are found in such close conjunction. The Upper Magnesian Limestone is only seen in small outliers in the immediate neighbourhood of Wetherby, one of which crowns Crow Croft Bank with a clearly defined cap. To the east and south this upper bed forms a well-marked escarpment, parallel to the escarpment of the Lower Limestone at a distance of three or four miles.

The Leader here gave some interesting details about the beds in question. The Permian formation west of the Pennine range runs in a narrow strip from the Durham coast through Yorkshire to Nottingham, and passes eastwards under the newer beds of Lincolnshire. The western face of the outcrop forms a marked double escarpment overlooking the low undulating land of the Coal Measures. The eastern face is usually covered with drift, which obscures the junction with the overlying Triassic beds. The Permian beds of Yorkshire were deposited in a closed sea, which stretched eastwards over Europe, and of which the Pennine chain formed the western boundary. Magnesian Limestone, often called dolomite after the geologist Dolmieu, consisted of a mixture of the carbonates of lime and magnesia in varying proportions. The normal dolomite contained 50 per cent. of carbonate of magnesia, but the proportion sometimes fell as low as 8 per cent. Mr. Kendall then, at the leader's request, made some further remarks on the origin of the Magnesian Limestone. It appeared to have been formed in a closed sea, which was subjected to concentration by rapid evaporation. Such a condition of things would be inimical to life, and hence the scarcity of fossils. Those sea-water forms that succeeded in defying the changed conditions would assume irregular or dwarfed shapes, and thus arose such forms as *Productus horridus*. The dolomitisation of the limestones was probably largely due to subsequent chemical action, by which water containing carbonate of magnesia in solution acted on the limestone, dissolving part of the carbonate of lime, and leaving carbonate of magnesia in its place. Such chemical action as this would result in a considerable reduction of volume in the mass of the limestone, and if produced thus we should expect a

dolomitic limestone to be fissured and cavernous. Cavities and cracks lined by tiny rhombohedral crystals of calc spar and dolomite were seen to be frequent in the limestone scar, under the grateful shade of which we stood, and it was stated as confirmatory evidence that at Micklefield, where the rock was a true dolomite, having 50 per cent. of carbonate of magnesia, it was very much more cavernous than the Wetherby rock, which contained a much smaller proportion of magnesia. In Ireland, Mr. Kendall stated, the large proportion of the Mountain Limestone was dolomitic, but the alteration had gone on irregularly, independently of the bedding. The formation of the inland Permian Sea appeared to have commenced in Coal Measure times. In the Lower Coal Measures there were evidences of numerous incursions of marine organisms. In the Middle Coal Measures these incursions became much less frequent, whilst in the Upper Coal Measures the evidence pointed to a closed lake, which was probably due to the lessened rainfall. In accordance with this evidence, we find that there are dolomitic limestone beds in the Upper Coal Measures. The overlying Trias beds are unconformable to the Permian, but not to the same extent as is the case between the latter and the Carboniferous. At Stockport, lately, evidence had been obtained of unconformability during the Permian period. Two large beds of marl with interbedded sandstone were found to be separated from the Collyhurst sandstone (Lower Permian) by a bed of conglomerate, which was evidence of an old river valley in Permian times, along the present site of the valley of the Mersey, the similarity in direction of the two being accidental.

The leader pointed out the connection between the bend of the river and the direction of the principal joints of the limestone; also it was evident that a soft yellow bed at the base of the cliff by its more rapid disintegration had greatly aided in the weathering back of the escarpment by undermining the more compact rock above. A very pleasant and instructive afternoon was concluded by an excellent tea at the Angel Hotel, after which hearty votes of thanks were awarded to the Leader and Mr. Kendall for their lucid expositions of the various points of interest in the excursion.

SEPTEMBER 2ND, 1893.

EXCURSION TO ROMBALD'S MOOR.

Leader, Mr. PERCY F. KENDALL, F.G.S.

The members of the Leeds Geological Association had a pleasant afternoon on the moorlands between Shipley and Ilkley, on Saturday, September 2nd. The party went from Leeds by the 2.12 train, and on alighting at Saltaire started up Shipley Glen, under the leadership of Mr. Percy F. Kendall, F.G.S. The path first led through a wood which had overgrown a talus from the Millstone Grit escarpment above, reminding the members vividly of Meanwood Wood. Time did not allow of the exploration of the deep and interesting gorge carved out of the grit beds by Loadpit Beck, so the well-trodden path was

followed, and the party pressed upwards to the moorlands, over the firm beds of the Rough Rock, highest of the Millstone Grit series. To the right rose the steep slope of Baildon Common, composed of the Lower Coal Measures or Ganister beds, the hard capping calliard forming a marked escarpment along the sky line. A peep or two on the other side into the gorge showed how the ceaseless working of the stream had mastered the solid grit, and washed out softer or shaly bands, causing the overlying massive beds to part along joint faces, and lean over in picturesque masses towards the Glen. Good instances of false bedding were seen in the sections thus exposed, telling of the conflicting currents to which the waters were subjected in which the grit beds had been laid down. As the party moved upwards the view opened out behind over Harden Moor, and the surrounding table-land, cut into by the well-marked gorge of the Aire at Steeton. The more distant heights were veiled in mist, and only gave vague indications of their presence, and as we gazed around we could not but recall our enthusiastic geological friend who had just passed from us to fairer scenes and a brighter sun, and it was with deep and sincere regret that we felt that no more could we have Mr. Cheetham's genial company on our moorland rambles, nor hear his enthusiastic and stirring descriptions of the hills and dales he loved so well. A steady climb under Eldwick Crag over wide expanses of heath and ling, brought us to the gently sloping table-land of Bingley Moor, consisting of the same Rough Rock along the dip slopes of which we had been walking since Shipley Glen was left behind. Monotony characterises this bleak moorland flat, and the heavy atmosphere yielded little of the refreshing breeziness which one expects on the heights above Ilkley. The ridge of Lanshaw Delves being sighted, a diversion was made across country for their examination, which really was the chief object of the excursion. This ridge, which extends for three-quarters of a mile in an easterly and westerly direction, consists of a mass of debris in which are fragments of the dark limestones and black cherts so characteristic of the Carboniferous Limestone beds of Upper Wharfedale. So plentiful were the limestone blocks once upon a time, that the ridge has all been turned over to find them, and the remnants of one of the primitive kilns in which they were collected and burnt for lime still remained for examination. On the road to Ilkley similar linear mounds were crossed, running generally in the same direction, and being, as our leader explained, the lateral moraines of the Wharfedale glacier, as it partly over-lapped the moorland, and pushed out a tongue over the col, at Menston, into the valley of the Aire. The mass of moraine debris found between Menston and Yeadon shows how considerable this glacial branch must have been, and in the excursion to Intake Gate last year, the Association had evidence of the continuation of the lateral moraine high up on the moorlands, in the mounds of Intake Delves. In support of this contention, Mr. Walker, of Benton, was able to testify that the glacial groovings found on the top of the quarries, near the Cow and Calf, ran from N.W. to S.E., which is the direction one would expect the Wharfedale glacier to take if the Delves were its lateral rubbish heaps. A rapid descent into the

Valley of the Wharfe, and a taste of the generous refreshment which Ilkley is so well able to afford to the hungry pedestrian, brought our ramble to a pleasant close.

SEPTEMBER 7TH, 1893.

EXCURSION TO POCKLINGTON.

YORKSHIRE NATURALISTS' UNION.

Looking at the Geological map, the town of Pocklington, situated as it is on the Keuper Marls, just outside the western fringe of the Chalk Wolds, with the Lower Lias intervening, appears, and actually is, an excellent centre for geological research. But it must be confessed that our geological party, chiefly through the want of a local guide, were able to do but scant justice to the district.

As suggested in the printed programme, the geologists assembled at Nunburnholme Station, and during the pleasant walk between that place and Wartar Priory, caught good views of the escarpment of the Wolds to the east, but did not see any open sections. Near the village of Wartar the famous brickfield mentioned by Tate and Blake was visited, and although much overgrown and obscured by slips, proved a most interesting section.

Here the Red Chalk was seen to rest directly on the Lower Lias, a fact which bears eloquent witness to the amount of denudation accomplished in this area during the Secondary Period. Here also a few common Lower Lias fossils were obtained, and Professor H. J. Johnstone-Lavis, F.G.S., who was a member of the party, secured a fine specimen of *Pleurotomaria*, species not yet determined.

Leaving the brickyard and taking the road to Pocklington, one or two unimportant sections in the Lower Chalk were noted.

Nearing Pocklington the hill to the north-east of the town was ascended, and on the brow the Lower Lias was found well exposed; but the upper part of the hill appeared to be covered with chalk debris.

The Sectional and General Meetings were held at the Feathers Hotel, Pocklington, under the presidency of Mr. A. H. D. Leadman, F.S.A. The Geological Report was presented by Mr. J. W. Stather, F.G.S., one of the Sectional Secretaries.

SEPTEMBER 23RD, 1893.

VISIT OF THE COUNCIL TO REV. H. CANHAM'S COLLECTION OF "CRAG" FOSSILS.

Geologists whose work has been confined to the well-consolidated rocks of northern England, find themselves in a new land, geologically speaking, when they travel south-eastwards into East Anglia and the basin of the Thames. There they find great deposits of sand, clay, and shells, belonging to the Tertiary period, which are soft and have only been very imperfectly cemented together. At the top of these

Tertiary beds stand certain deposits of shelly sand called "crag," the name being a local term meaning "broken," and referring to the ragged appearance of the deposits. These beds occur in patches on the eastern borders of Norfolk, Sussex, and Essex, and belong to the Pliocene or uppermost division of the Tertiary strata. They have been divided into two principal sections, the Norwich Crag or newer Pliocene, and the Red and Coralline Crags, which together form the older Pliocene. Commencing at the lowest of the Pliocene deposits, the Coralline or Suffolk Crag, we find a series of shelly sands, from 40 to 60 feet in thickness, crowded with the remains of mollusca and bryozoa, sometimes well-preserved, but usually much broken up. At the base of these beds is the Suffolk Bone-bed, composed of rounded phosphatic nodules called "coprolites," and water-worn teeth and bones of mastodon, rhinoceros, tapir, bear, whale, and shark. At Orford this bed lies on a surface of denuded London Clay. Overlying the Coralline Crag is a dark red, shelly deposit, showing frequent oblique bedding, called the Red Crag. At its base there is also a bed of "coprolites," which have been worked for artificial manure, containing phosphatic nodules, and the remains of the denudation of older deposits, such as fragments of septaria and fossil crustacea from the London Clay, chalk flints, water-worn bones and teeth of whales, dolphins, sharks, etc. Above the phosphate bed comes a series of beached-up deposits inclined at angles of 25 to 35 degrees, and dipping in a nearly constant direction. These inclined deposits are probably the remains of a series of banks left dry at every tide, and occasionally washed away and re-accumulated. They form a shelly reef, or foreshore deposit, extending from the River Alde southwards into Essex. In marked contrast to these deposits the top bed of the Red Crag is horizontal, and was formed on the bed of a shallow sea which washed out channels in the existing reef. Newer than the Red Crag deposits are certain beds of shelly sand, clay, and shingle, which occur in scattered patches in eastern Norfolk, resting on an eroded surface of Chalk, and overlaid by glacial deposits. The Norwich Crag, as these upper Pliocene beds are called, has near its base a "stone" bed containing many mammalian remains, and in its upper parts it passes into beds of clay and micaceous sand. All through this series we have evidences of a gradual change of climate, from the tropical Eocene times to the glacial cold of the Pleistocene. In the Coralline Crag the sea was much warmer than is the case at present, and probably resembled the Mediterranean in many of its characteristics. A considerable interval seems to have taken place between the deposition of the Coralline Crag and the overlying Red Crag—an interval sufficient to allow of the denudation of a large portion of the older deposit. Throughout Red Crag times there was a gradual cooling. Evidences of drift-ice are more common, and northern forms of mollusca increase as we rise in the series. The continuation of this process of transition is seen in the Norwich Crag, until the Arctic conditions of the glacial epoch are reached.

One of the most industrious workers in these East Anglian deposits was the Rev. Henry Canham, Rector of Leathley, who, when

Vicar of Waldringfield, Suffolk, made the famous collection of fossils that bears his name. By his kindness the Council of the Leeds Geological Association were enabled to inspect the numbers of beautiful fossils that he obtained by persisent labour and careful watchfulness. Twenty years ago the "coprolite" pits were in active operation, and many fine specimens were then obtainable that are now quite out of the collector's reach. Mr. Canham's collection contains the type specimens of many species figured by the late Mr. Searles V. Wood, e.g., Fusus elegans. Several species have been named after Mr. Canham, their discoverer, as Murex Canhami and Halitherium Canhami. The latter is an extremely interesting specimen, being the first fossil manatee found in this country. A large portion of the collection is in the Ipswich Museum, but a vast number of rare and beautiful shells were shown to the geological party, notably Mactra glauca, a suite of specimens of Cassidaria bicatenata, of Voluta Lamberti, and of Emarginula crassa. The vertebrate remains were extremely valuable and interesting. There were palates of fishes of the genera Myliobatis, Phyllodus, Elasmodus, and a magnificent and perfect palate of a large Pycnodus. The first three were probably washed into the Red Crag deposit, from which Mr. Canham obtained them, out of denuded beds of London Clay. The Pycnodus must have been derived from some Secondary deposit. Among the mammalian remains were splendid teeth of mastodon, many teeth and ear-bones of whales and dolphins, and several fine rostra of xiphioid whales. The courteous kindness and genial hospitality of Mr. and Mrs. Canham were thoroughly appreciated by the Leeds geologists, and their delight at the treat afforded them was very heartily expressed by Mr. John Ingleby (president), Mr. P. F. Kendall, and Rev. W. L. Carter (secretary). A pleasant drive back to Leeds terminated a very enjoyable afternoon's outing.

APRIL 21ST, 1894.

EXCURSION TO MARSH LANE CUTTING.

Leader, Mr. PERCY F. KENDALL, F.G.S.

A second excursion was made to this interesting cutting in order to examine the sections which have been more fully exposed during the progress of these extensive excavations. The excursion was well attended, and included members of the Geological Class at the Leeds School of Science, and other visitors, as well as a good number of the members of the Association.

The party met at Pontefract Lane Bridge and proceeded to the east end of the Railway Cutting, where the junction of the Middle and Lower Coal Measures on a line of fault was observed. Wandering along the north side of the Cutting the Lower Coal Measures were seen, and the Members were soon busily engaged in fossil hunting. Anthracosia were abundant, and some good specimens of plant remains were obtained, including Calamites, Spherophyllum, and Neuropteris. Excellent examples of false-bedded sandstones, and an interesting

section of an old river-channel, gave some interesting and instructive lessons of the work of geological agencies in those primeval ages.

MAY 14TH, 1894.

EXCURSION TO SEDBERGH.

YORKSHIRE NATURALISTS' UNION.

Physically and geologically the country immediately around Sedbergh belongs to the Lake District, and there, within the borders of our own county, may be studied several members of the Silurian system which are so extensively developed in certain localities of the lake country as to derive their distinctive names therefrom.

There, too, are to be seen interesting sections of the "Old Red Conglomerate," at one time considered to be Devonian, but now regarded as "Carboniferous Basement Beds," while to the N.E., across the Dent or Pennine Fault, is seen the Great Scar Limestone, followed by a whole series of Yoredales, with the Millstone Grit on the highest ground. Intrusive igneous rocks in sills and dykes in all the Silurians afford additional interest to the petrologist, while the glacial deposits on which the town of Sedbergh stands, and which appear in some of the gills skirting the valley to the N.W., present material deserving the careful attention of the glacialist. A district affording so extensive a series could not fail to supply abundant work for the time at the disposal of the visitors. The geologists who had the good fortune to arrive on the Saturday, were usefully introduced to their subsequent investigations by the exhibits thoughtfully provided at the conversazione in the evening by the Rev. J. H. Mackie, M.A., and Mr. Hugh Richardson, M.A. These included maps of the district, hand specimens of local rocks, both sedimentary and igneous, a few characteristic fossils, and excellent lantern views of some of the most striking sections. To these were added microscopic sections of local mica-traps and felsites prepared and sent by the President of the Geological Section, Mr. Thomas Tate, F.G.S.

The advance party first devoted their attention to the "Old Red Conglomerate" through which the river Rawthey runs at and above Straight Bridge. It consists here, as elsewhere, of a coarse conglomerate of rounded, subangular, and angular fragments of the Silurian rocks, ranging from the smallest grains to blocks two feet in diameter. These are enclosed in a dark red clayey and sandy matrix, and interstices are occasionally filled with calcite. One specimen obtained contained a large crystal of pink orthoclase, presumably from Shap Granite, which had been previously noted by Mr. Goodchild and Prof. H. Alleyne Nicholson as occurring in the Basement Beds between Shap and Tebay. Evidence of stratification appeared in a larger section 200 yards up stream, and an apparent imbrication of the contained fragments suggested that the direction of deposit was approximately that of the present stream. Mr. Tiddeman had previously stated that these "Basement Beds have every appearance of having been deposited in valleys." Subsequently the party worked over the Coniston Grits,

of Winder, examined and photographed the glacial moraine in the gill below the rifle butts; and, crossing the heather-grown ridge above, climbed to the summit of Arant Haw (1,950 feet). Geological investigations were here suspended to admire the scene. Westwards lay in full view the Lune Valley, Morecambe Bay, the Limestone plateau behind Grange, and a splendid series of the Lake Mountains. Around were the Howgill Fells, with rounded tops and steep slopes coloured with the varying shades of a new spring vegetation, while further away to the N. and N.E. the hills in the distance showed the characteristic contours of the Millstone Grit. Sea and river, wild mountain and peaceful valley were all spread out to view, and formed a picture for memory to happily recall for many a day. What with bad weather on one hand, and an excellent programme arranged by Mr. Richardson on the other, the geologists had more than their work cut out when the main body arrived on the Monday forenoon. Nothing daunted, however, a start was made, led by the President of the Union and Mr. Richardson, to ascend the Rawthey across the Dent Fault, the members gaining much assistance from the detailed notes given in the programme by Mr. Aubrey Strahan, F.G.S. The party drove in a wagonette about six miles to Rawthey Bridge, the "Old Red Conglomerate" being pointed out to the new comers at Straight Bridge. Thence along the Silurians, noting the chief physical features of the country, and passing Cautley Spout in the Coniston Grits across the valley. At the Cross Keys the road passes on to the Coniston Flags, and the members, now on foot, proceeded to examine the river bed, and specimens of the mica-trap dykes which cross the stream were secured. Passing Rawthey Bridge, near which the river enters twice through Graptolitic Mud-stones, the crushed Silurians soon indicated the proximity of the Dent or Pennine Fault, which was soon reached, and the Carboniferous Limestone was at once in evidence, as shown not only by its outcrop, but its characteristic vegetation. Sections exposed in the river bed are vertical. At this point the geologist is reminded of the peculiar feature which the Rawthey has in common with the Lune, the Dee, and the Clough. Rising in the Carboniferous system to the N.E., the river flows S.W. across the fault from the downthrow to the upthrow side, passing thus from the newer to the older rocks, and on to an area which has undergone greater elevation than that in which the river rises. Proceeding, in a short distance a cave was noted, but it was too wet to explore its recesses. Yoredale sandstones and shales followed, and as the distance from the fault increased the Hardraw Scar Limestone appeared approaching the horizontal again. Time now compelled a return, so the party turned backward, at an angle of about thirty degrees with the river, across the moor, and passing a row of pot-holes indicating the line taken by the vertical limestone beds previously seen in the river, the members climbed up to the diabase capping Blue Caster. Thence down to the Cross Keys again, and back to Sedbergh, passing a very hearty vote of thanks to Mr. Richardson en route.

The usual meetings were held at the Bull Hotel, under the presidency of Mr. Robt. Tiddeman, M.A., F.G.S. In the absence of

the Sectional Secretaries, the Geological Report was furnished by Mr. J. H. Howarth, F.G.S.

JUNE 16TH, 1894.

EXCURSION TO FERRYBRIDGE.

YORKSHIRE NATURALISTS' UNION.

The one-hundred-and-ninth meeting of the Yorkshire Naturalists' Union was held at Pontefract, for the examination of the neighbourhood round that town, and between it and Ferrybridge. The beds examined belong chiefly to the Permian series, and consist of the Lower and Upper Magnesian Limestones, parted by the Middle Marls, which form slight parallel escarpments to the north of Brotherton. The Upper Limestone was well seen in the quarries to the north of Brotherton, and a short halt was made whilst a brief account was given by one of the leaders (Rev. W. L. Carter) of the origin and stratigraphical importance of the Permian Beds. Passing on to the Great North Road, the party retraced their steps to Ferrybridge, and made a traverse across the country to Pontefract, excellent sections of both Upper and Lower Limestones being seen in the railway cuttings. On arriving at the Pontefract Station some time was devoted to the examination of the sandstone rock, about the stratigraphical position of which much controversy has raged. The sections were much overgrown, and several critical points could not be examined, but the evidence seemed conclusively to point to the Carboniferous age (Millstone Grit) of these beds. The party was swelled by a large contingent of the boys from Ackworth School, and a contingent of the members of the Leeds Geological Association came over for the afternoon tramp.

List of Presidents.

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PROF. A. H. GREEN, F.R.S., F.G.S.

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1886-88. C. D. HARDCASTLE.

1888-90. JAMES E. BEDFORD, F.G.S.

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*Those who have contributed Papers or conducted Excursions are distinguished by an asterisk **

Year of Election.

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1874 *Miall, Professor L. C., F.R.S., F.G.S., F.L.S., Highfield, Ben Rhydding.
1887 *Sollas, Professor W. J., D.Sc., F.G.S., 4, Clyde Road, Dublin.
1887 *Spencer, Jas., 8, Salisbury Place, Akroydon, Halifax.
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1891 Bailey, John Wm., 11, Bond Street, Leeds.
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1874 *Bell, Thos. W., 10, Winfield Mount, Blackman Lane, Leeds.
1889 *Bingley, Godfrey, Thornehurst, Shaw Lane, Headingley, Leeds (*Member of Council*).
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1889 Burlend, Geo., Newthorpe Lime Quarries, near South Milford.
1887 Carter, Geo. F., Boro. Engineer's Dept., Municipal Buildings, Leeds.
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1893 Carter, Mrs. W. L. do.
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1886 Crowther, J. A., Borough Engineer, Bootle, Liverpool.
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1893 Darling, C., 11, Brudenell Grove, Leeds.
1893 Dean, J. B., F.R.H.S., 45, Queen Street, Melbourne, Victoria.
1893 Dowgill, Alfred, Vernon Road, Leeds.
1892 Earle, Richard, 40, Sholebroke Avenue, Leeds.
1887 Ellis, Edward, A.M.I.C.E., Springfield House, Bramley.
1889 *Farrar, Abm., Junr., F.G.S., The Grange, Beech Grove, Harrogate.
1887 *Fitton, Wm. H., F.G.S., 6, Bersham Road, Wrexham.
1891 *Forsyth, David, M.A., D.Sc., 2, Lifton Place, Leeds (*Member of Council*).

1889 Gibbins, Henry, 7, Winstanley Terrace, Victoria Road, Headingley.
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1889 Gummerson, Chas. J., 7, Winstanley Terrace, Victoria Road, Headingley.
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1893 Kendall, Mrs. P. F. do. do.
1893 Kirk, Albert, Buckingham Villas, Headingley.
1893 Lang, Joseph, 64, Samuel Street, Camp Road, Leeds.
1893 Litton, Robt. T., 45, Queen Street, Melbourne, Victoria.
1892 Lofthouse, J. H., 42, Mayfield Grove, Harrogate.
1893 McKnight, T. H., F.G.S., 45, Queen Street, Melbourne, Victoria.
1889 Matthews, Fredk. J. Arundel, F.G.S., Holly Ridge House, Headingley.
1887 *Metcalf, W. Day, Boroughbridge, *via* York.
1889 Mitchell, Fred, 98, Albion Street, Leeds.
1893 Monteith, Alexander, Boar Lane, Leeds.
1893 Monteith, Alexander, Junr., Low Hall, Horsforth.
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1893 Moss, S. R., 50, Ella Street, Leeds.
1886 Mylne, J. W., Elmwood Mills, Leeds.
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1892 Nicholson, John, Chapeltown, Pudsey.
1893 Noble, Arthur, 28, Banstead Terrace, Roundhay Road, Leeds.
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1893 Payne, E., M.I.M.E., 37, Sturt Street, Ballarat, Victoria.
1886 Pheasey, J., 176, Woodhouse Lane, Leeds.
1874 *Pocklington, H., F.R.M.S., 41, Virginia Road, Leeds.
1891 Pollard, James, 28, Tonbridge Street, Leeds.
1885 *Redmayne, John, Grove House, Headingley.
1893 Reid, Vernon B., Park Row, Leeds.
1885 Ripon, The Most Hon. The Marquis of, K.G., Studley Royal, near Ripon.
1881 Roebuck, W. D., F.L.S., Sunny Bank Terrace, Leeds.
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1893 Sanderson, Wright, Armley Villas, Armley, Leeds.
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1892 Scott, Robert, 21, New Briggate, Leeds.

1893 Simpson, Sidney F., Vincent Place, Hunslet.
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1893 Tomlin, J. H., F.R.G.S., Bramley.
1885 Wade, Adam, Millshaw, near Leeds.
1892 Wainwright, E. W., Brooklyn, Birstall.
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1889 Wilkinson, J. J., Burnside, Skipton (*Member of Council*).
1891 Witts, J. W., Borough Engineer's Office, Leeds.
1885 Wood, R. H., 15, Bainbrigge Road, Headingley.

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1893 Hives, John, 20, Victoria Mount, Woodsley Road, Leeds.
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„ Clarke, P. T., 31, Gathorne Terrace, Leeds.
„ Clarke, T., B.A., 8, Alexander Terrace, Bray, County Wicklow.
„ Church, Miss Emma, 45, Northcote Terrace, Leeds.
„ Wadsworth, Miss Martha B., 154, Lady Pit Lane, Beeston Hill, Leeds.
„ Walker, H. A., 49, Bagby Road, Leeds.
1894 Bond, John Wm., Torre Road, Burmantofts, Leeds.

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„ Loftus, Douglas L., 68, Victoria Road, Leeds.
„ Haigh, Fred H., 138, Chapeltown Road, Leeds.
„ Bennett, Duncan, 12, Louis Street, Leeds.
„ Harrison, William, 13, Brunswick Street, Leeds.
„ Wright, Thomas, 296, Meanwood Road, Leeds.
„ Forsyth, J., 2, Lifton Place, Leeds.
„ Wade, F., 39, Leopold Street, Leeds.
„ Lyon, R., 17, St. James' Street, Leeds.
„ Scholes, P., 34, Headingley Lane, Leeds.

LEEDS GEOLOGICAL ASSOCIATION.

ABSTRACT OF ACCOUNTS. SESSION 1893-94.

RECEIPTS.

	£	s.	d.
To Balance in hand	3	2	9
„ Subscriptions, 1893-94	21	6	0
„ Do. 1894-95	1	12	6
„ Do. Arrears	1	15	0
„ Sale of Transactions	0	4	6
	£28	0	9

Examined and found correct, 28*th Aug.*, 1894,

W. Lower Carter,

James Gurnell.

EXPENDITURE.

	£	s.	d.
By Printing and Stationery	15	3	0
„ Postages: Hon. Secretaries	7	19	0
„ Do. Hon. Treasurer	0	2	6
„ Collector: Commission and Expenses	0	13	0
„ Subscription: Leeds Photographic Club ...	0	10	0
„ Do. Annals of Geology	0	10	6
„ Do. Yorkshire Naturalists' Union ...	0	11	0
„ Mechanics' Institution: Rent of Rooms ...	1	2	6
„ Do. do. Caretaker	0	10	0
„ Balance in hands of Treasurer	0	19	3
	£28	0	9

Leeds Geological Association.

OBJECT—The object of this Association is to promote the study of Geology by means of field excursions, exhibition of specimens, reading of original papers, and discussions.

MEETINGS—The Meetings are held on the third Thursday evening in each month, at Half-past Seven o'clock, in the Old Chemical Lecture Room, Mechanics' Institution, Cookridge Street, Leeds. Previous to each meeting, from 7 o'clock to 7.30, there will be an exhibition of specimens in the same room.

EXCURSIONS—Excursions are frequently taken to places of geological interest, under the guidance of experienced geologists.

YORKSHIRE NATURALISTS' UNION—The Association being affiliated with the Yorkshire Naturalists' Union, each Member and Associate has the title and privileges of an Associate of the Yorkshire Naturalists' Union, and is regularly notified of their Excursions.

Members may introduce their friends (ladies and gentlemen) at the Meetings and Excursions of the Association.

Membership and Subscription.

ORDINARY MEMBERS—Receive the Transactions of the Association as published, and have special notification of all Meetings and Excursions.

One Copy of the Transactions.		5/-	per annum.
Three Copies	ditto	10/-	ditto
Five Copies	ditto	15/-	ditto
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ASSOCIATES—Assistant Teachers in the Schools of the City, and others as the Council of the Association may determine, may become Associates. Subscription :—Two Shillings and Sixpence per annum.

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The conduct of the Affairs of the Association is vested in the Members.

The Subscriptions are due on July 1st in each year, and should be paid to the Treasurer of the Association.

Members changing their addresses are requested to communicate with the Hon. Secretary, Mr. James H. Howarth, Newton Crescent, Leeds, from whom also forms of Nomination for admission to membership can be obtained.